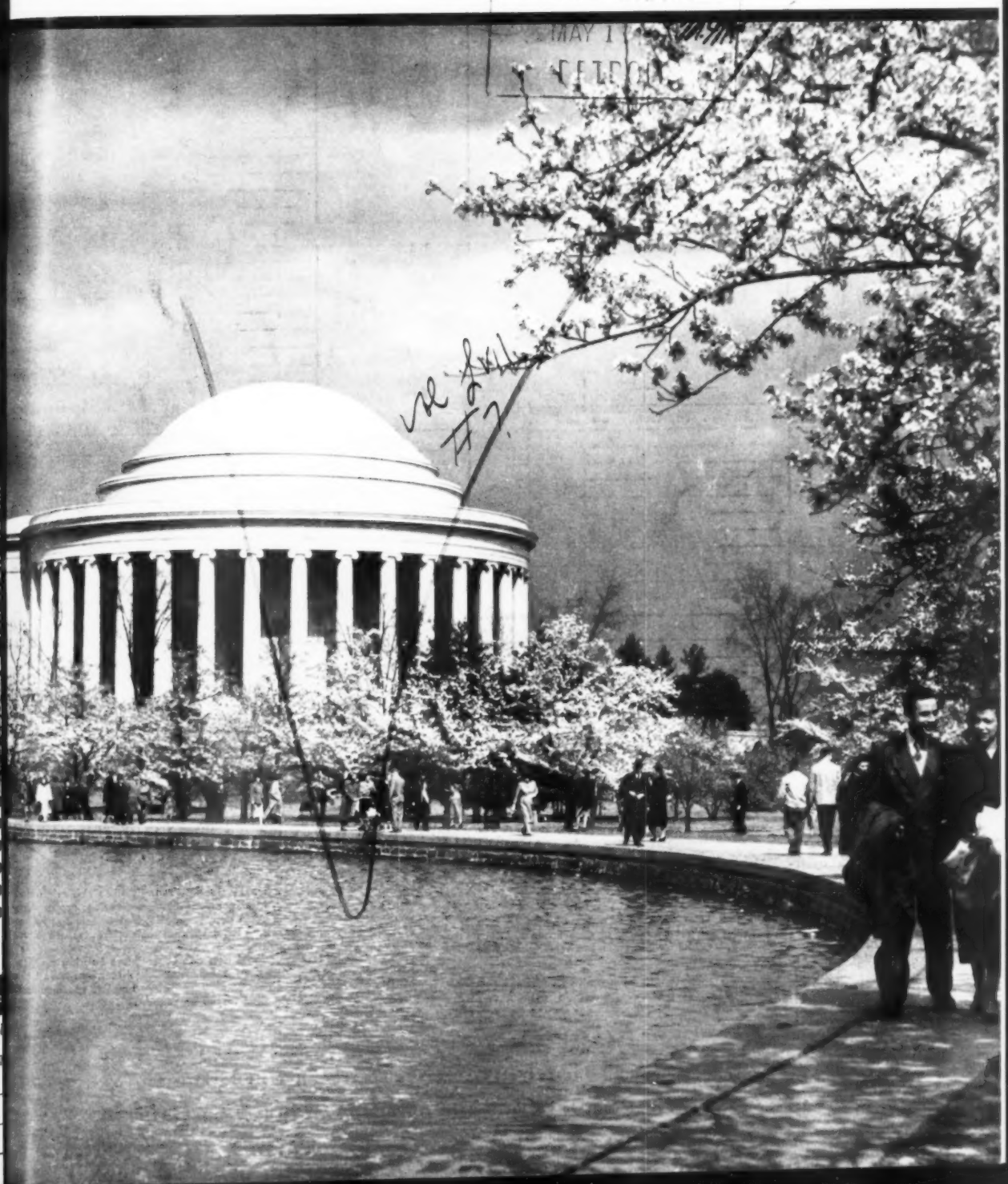
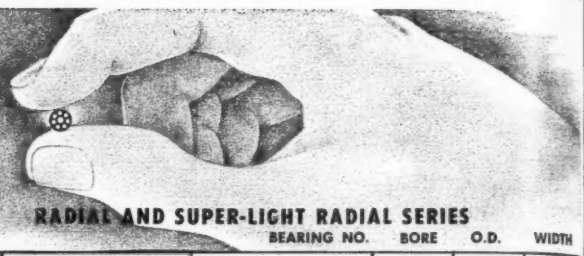
TECHNOLOGY REVIEW

May 1955



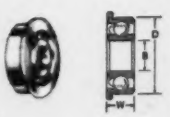
MPB miniature ball bearings offer a ready solution to many difficult miniaturization projects involving space, weight and friction.



RADIAL RETAINER SERIES

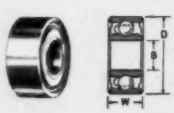
BEARING NO.	BORE	O.D.	WIDTH
2½C	.0469"	.15625"	.0625"
▼3C	.0550"	.1875"	.0781"
§▼4C	.0781"	.2500"	.0938"
§▼5C	.09375"	.3125"	.1094"
3332C	.09375"	.1875"	.0625"
§418C	.1250"	.2500"	.0938"
§▼518C	.1250"	.3125"	.1094"
§▼5532C	.15625"	.3125"	.1094"
§▼5632C	.1875"	.3125"	.1094"
§▼618C	.1250"	.3750"	.1094"
§▼6632C	.1875"	.3750"	.1250"
§614C	.2500"	.3750"	.1250"

FLANGED RADIAL SERIES *(Full Race or Retainer Type)*



		BORE	O.D.	WIDTH
2½F	2½FC	.0469"	.15625"	.0625"
▼3F	3FC	.0550"	.1875"	.0781"
▼4F	4FC	.0781"	.2500"	.0938"
▼5F	5FC	.09375"	.3125"	.1094"
3332F	3332FC	.09375"	.1875"	.0625"
418F	418FC	.1250"	.2500"	.0938"
▼518F	518FC	.1250"	.3125"	.1094"
▼5532F	5532FC	.15625"	.3125"	.1094"
▼5632F	5632FC	.1875"	.3125"	.1094"
▼618F	618FC	.1250"	.3750"	.1094"
▼6632F	6632FC	.1875"	.3750"	.1250"
614F	614FC	.2500"	.3750"	.1250"

DOUBLE SHIELDED RADIAL RETAINER SERIES



BEARING NO.	BORE	O.D.	WIDTH
2½CHH	.0469"	.15625"	.0938"
3CHH	.0550"	.1875"	.1094"
4CHH	.0781"	.2500"	.1406"
5CHH	.09375"	.3125"	.1406"
418CHH	.1250"	.2500"	.1094"
518CHH	.1250"	.3125"	.1406"
5532CHH	.15625"	.3125"	.1250"
5632CHH	.1875"	.3125"	.1250"
618CHH	.1250"	.3750"	.1406"
6632CHH	.1875"	.3750"	.1250"
614CHH	.2500"	.3750"	.1250"

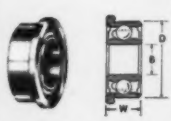
PIVOT SERIES

BEARING NO.	BORE	O.D.	WIDTH
1½PR	.020"†	.0590"	.0472"
3PR	.030"†	.1181"	.0709"
▼4PR	.040"†	.1575"	.0945"
▼5PR	.050"†	.1968"	.1181"
▼7½PR	.075"†	.2953"	.1772"
▼10PR	.100"†	.3937"	.2362"

RADIAL AND SUPER-LIGHT RADIAL SERIES

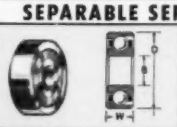
BEARING NO.	BORE	O.D.	WIDTH
100	.0250"	.1000"	.0312"
2	.0400"	.1250"	.0469"
2½	.0469"	.15625"	.0625"
▼3	.0550"	.1875"	.0781"
▼4	.0781"	.2500"	.0938"
▼5	.09375"	.3125"	.1094"
3332	.09375"	.1875"	.0625"
418	.1250"	.2500"	.0938"
▼518	.1250"	.3125"	.1094"
▼5532	.15625"	.3125"	.1094"
▼5632	.1875"	.3125"	.1094"
5732	.21875"	.3125"	.1094"
▼618	.1250"	.3750"	.1094"
▼6632	.1875"	.3750"	.1250"
614	.2500"	.3750"	.1250"

DOUBLE SHIELDED FLANGED RADIAL RETAINER SERIES



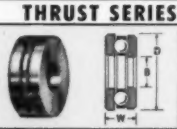
2½FCHH	.0469"	.15625"	.0938"
3FCHH	.0550"	.1875"	.1094"
4FCHH	.0781"	.2500"	.1406"
5FCHH	.09375"	.3125"	.1406"
418FCHH	.1250"	.2500"	.1094"
518FCHH	.1250"	.3125"	.1406"
5532FCHH	.15625"	.3125"	.1250"
5632FCHH	.1875"	.3125"	.1250"
618FCHH	.1250"	.3750"	.1406"
6632FCHH	.1875"	.3750"	.1250"
614FCHH	.2500"	.3750"	.1250"

SEPARABLE SERIES



3M	.0550"	.1875"	.0781"
4M	.0781"	.2500"	.0938"
5M	.09375"	.3125"	.1094"
518M	.1250"	.3125"	.1094"
618M	.1250"	.3750"	.1094"

THRUST SERIES



2T	.0400"	.1250"	.0625"
4T	.0938"	.2500"	.0938"
5T	.1250"	.3125"	.1250"
6T	.1875"	.3750"	.1500"
7T	.1250"	.4375"	.1875"

ANGULAR CONTACT SERIES

2A	.042"†	.1250"	.0469"
3A	.062"†	.1875"	.0700"
▼4A	.085"†	.2500"	.0938"
▼6A	.124"†	.3750"	.1406"
6A7B	.150"†	.3750"	.1406"

Prefixes indicate material: Standard is chrome bearing steel (SAE 52100): use no prefix. All bearings, except No. 100 and No. 1½P, also available in 440 stainless: use prefix SS in ordering. ▼Indicates also available in 25 beryllium: use prefix NM in ordering. §Indicates sizes available with spring separator, specify suffix S in place of C as shown. †Indicates minimum shaft (S) dimension, (SE) dimension on request. Single Shielded Radial Retainer Series also available, specify CH, dimensions identical to Radial Retainer Series with exception of following which are wider: 2½ CH (.0938), 3CH (.0938), and 4CH (.1094). Single Shielded Flanged Radial Retainer Series also available, all dimensions identical to Double Shielded Flanged Radial Retainer Series. Specify FCH and side to be shielded. Grooved Radial Retainer bearings are also available in 9 sizes. Root diameter of groove is the same as O.D. of equivalent Radial bearing. Details on request.

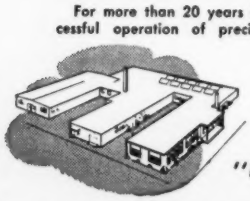
MPB ball bearings

are available in ten design series and in more than 400 different types and sizes which normally can be supplied from stock for prompt installation.

Instrument manufacturers and users of small precision mechanisms can now utilize all the well known extra advantages of anti-friction bearings (accurate alignment, long wear, freedom from attention) universally accepted in larger quality equipment.

For more than 20 years MPB ball bearings have contributed to the successful operation of precision mechanisms. A pioneer in designs and dimensions now being internationally standardized, MPB has also originated many precision manufacturing techniques. All MPB ball bearings are ground, lapped, honed and/or burnished in accordance with highest quality practice for optimum operating characteristics. Inspection limit tolerances are equal to ABEC 5 or better.

The most extensive engineering knowledge in miniature bearing applications is available to you. More than a million MPB ball bearings have been installed in precision mechanisms. Catalog 54 giving complete specifications, and additional data sheets mailed to you on request.



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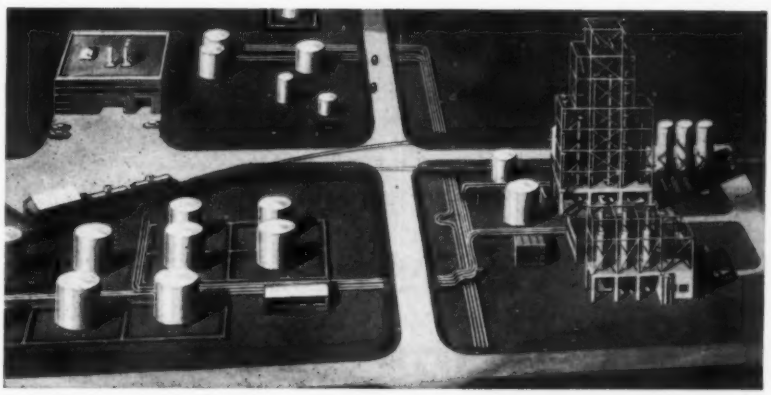
LUMMUS TO BUILD AIR REDUCTION CHEMICAL'S VINYL ACETATE PLANT AT CALVERT CITY, KENTUCKY

Lummus-Built Plant To Come On Stream In Early 1956



The 30,000,000 lb. per year vinyl acetate plant which The Lummus Company is engineering and constructing for Air Reduction Chemical Company, a division of Air Reduction Company, Inc., is a good example of how industry can set up an integrated plant in a strategic location, and insure maximum returns for its capital investment. The plant's attractive location at Calvert City, Kentucky has all the benefits of readily available power, natural gas, water transportation, and a host of related chemical products.

This $3,000,000 installation scheduled for completion early in 1956, is adjacent to the calcium carbide and acetylene plant of Air Reduction's National Carbide Division, and will receive pipeline acetylene from it. The new vinyl acetate plant will be a key development in Air Reduction's chemical expansion which begins with basic raw materials and ends with a variety of products having important commercial and industrial uses.

Vinyl acetate goes principally into polyvinyl acetate emulsions, used in adhesives, latex paints and textile finishes, and polyvinyl alcohol used for adhesives and textile finishes.

At Calvert City, in addition to this new Air Reduction plant, Lummus is also building a $6,000,000 high pressure acetylene derivatives plant for General Aniline & Film Corporation. What better example could be given to show that Lummus is ready, willing and able to design, engineer and construct your next chemical plant.

The Lummus Company, 385 Madison Avenue, New York 17, N. Y. **Engineering & Sales Offices:** New York, Houston, Montreal, London, Paris, The Hague, Bombay. **Sales Offices:** Chicago, Caracas. **Heat Exchanger Plant:** Honesdale, Pa. **Fabricated Piping Plant:** East Chicago, Indiana.

LUMMUS

THE TECHNOLOGY REVIEW, May, 1955, Newsstand Edition. Vol. LVII, No. 7. Published monthly from November to July inclusive at Emmett Street, Bristol, Conn. Publication date: twenty-seventh of the month preceding date of issue. Annual subscription $4.00; Canadian and Foreign subscription, $4.50. Entered as second-class matter December 23, 1949, at the Post Office at Bristol, Conn., under the Act of March 3, 1879.

Out of the desolate, flat land . . .

at Tuscola, Illinois, there has grown the giant plant of the National-Petro Chemicals Corporation, manufacturer of ethylene and many of its by-products.

Necessary to this installation is sufficient storage capacity to handle the materials used in its many processes. The tanks pictured above are part of more than 2,000,000-gallon storage capacity built by Graver. They contain sulfuric acid—an essential ingredient in the manufacture of ethyl alcohol from ethylene.

Graver is especially qualified to build special-purpose tanks like these at Tuscola, and also fabricates storage tanks of every size for all industrial needs. For 97 years Graver has been building tanks. . . . You can do no better than to supply your requirements from this experienced and dependable source.

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Spirafil coaxial signal cable was developed by Phelps Dodge as a companion cable to Styroflex coaxial cable. It is designed for specific use in applications where the precise Styroflex tape helix construction is not required.

This unique signal cable is made up of a solid copper center conductor, a solid polyethylene helix and an outer, tubular aluminum conductor.

Spirafil cable is particularly adaptable to use in community antenna systems. For this purpose, it has a number of outstanding features—*no radiation, low attenuation, excellent frequency response, uniform electrical properties over wide temperature variations* and *unlimited operating life.*

Spirafil cable is one of that select group of cables assigned the highest life expectancy rating.

These special Spirafil characteristics, together with the economical cost of the cable, also make it suitable for certain applications in VHF, UHF and microwave communications circuits.

Spirafil cable is manufactured in 1000-foot, continuous lengths without joints. A Habirlene(polyethylene)jacket is supplied for protection against corrosion when the cable is to be installed in underground ducts, under water, or buried directly in the ground.

* * *

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Today, the Mechanical Engineer's concern with dynamics leads him into every aspect of our industrial and domestic lives. He helps produce our automobiles, our clothing, our magazines . . . our electric power and our locomotives. He gives us all a far better life—and helps plan an even brighter future.

Because this vital profession is so far-reaching, no one man can encompass every part of it. Acting as storehouse of this accumulated knowledge—and spearheading the critical task of achieving tolerable systems of *standards* in such varied things as bolts, belts and boilers—is his society, the American Society of Mechanical Engineers.

This year, the A.S.M.E. is seventy-five years old. Of its fine record of achievement, it can be justly proud. And Combustion Engineering—which for generations has been benefited by, and in some measure has contributed to, the work of the society—is delighted to wish the A.S.M.E. a happy diamond anniversary.

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Chemical and Physical Properties

Silica Content (Moisture-Free Basis)	99.0 – 99.7%
Free Moisture (105° C.)	0.2 – 2.0%
Ignition Loss (1000° C.)	0.2 – 1.0%
CaO, MgO	0.00%
Fe_2O_3	0.004%
Particle Size Range	.015 – .020 micron
Surface Area (Nitrogen Adsorption)	175 – 200 m.²/gm.
Specific Gravity	2.1
Color	white
Refractive Index	1.55
pH (10% Aqueous Dispersion)	4.5 – 6.0
Oil Absorption (Gardner Method)	150 lbs. oil/100 lbs. pigment
Bulking Value	0.057 gal./lb.
Apparent Bulk Density	
Uncompressed Grade	2.5 – 3.5 lbs./cu. ft.
Compressed Grade	5.0 – 6.5 lbs./cu. ft.

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GEARS

THE TABULAR VIEW

Mainstay Meals. — Despite a vast, fertile land millions of square miles in extent, the early pioneers who settled on the Atlantic shores — whether at Boston, Plymouth, New Amsterdam, Jamestown, or St. Augustine — had to labor long, diligently, and skillfully to assure an adequate and dependable food supply. They were at the mercy of the vagaries of the weather and of the peacefulness of the Indians. They had no power machinery and had to import all but the few products they could build themselves in their local communities. The diet of these hardy settlers left much to be desired, according to modern standards, but they thrived, grew strong, and — building on individual freedom and initiative — carved a great nation out of the wilderness. How — and what — our ancestors ate is treated in the article "Food of Our Colonial Forefathers" (page 343) by HARRY W. VON LOESECKE. A graduate of Harvard University, Mr. von Loesecke was formerly research chemist for the General Electric Company, the American Protein Corporation, and the United Fruit Company. He has also been senior chemist, industrial specialist, and technical adviser in a variety of projects related to agriculture and the food industry. Mr. von Loesecke is a fellow of the American Public Health Association, and this year is chairman of its Food and Nutrition Section. He is a member of the American Chemical Society, and of the Institute of Food Technologists.

Iron Idyl. — Most of the high-grade iron deposits in areas within easy accessibility of major markets have long since been discovered and, if profitable, have also been developed. Lower-grade ore deposits are next to be developed, but occasionally a rich deposit in an out-of-the-way place is discovered. When this happens, much engineering effort and talent must be directed to the task of bringing the iron to salable markets. How this was done in the case of a rich deposit in Cerro Bolivar is described in "Iron Ore from Cerro Bolivar" (page 339) by RICHARD FINNIE. Historian of the world-wide Bechtel

(Concluded on page 324)

ALUMNI DAY, 1955
June 13 at M.I.T.

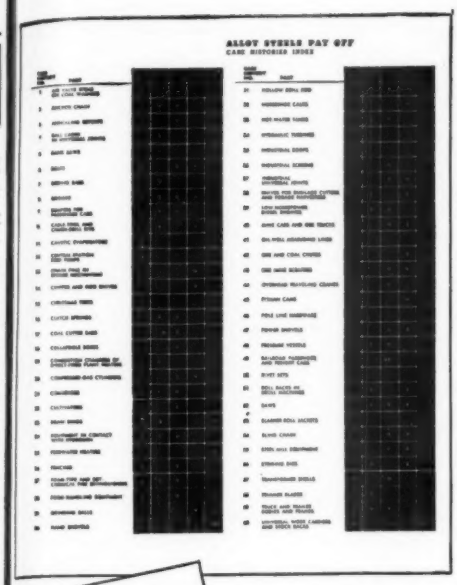
Emphasizing the Morning Conference—
"Uses and Economics of the Peaceful Atom"

Panel Participants:
JOHN VON NEUMANN, *Commissioner, Atomic Energy Commission*
DR. SHIELDS WARREN, *Professor of Pathology, New England Deaconess Hospital*
T. KEITH GLENNAN, *President, Case Institute of Technology*

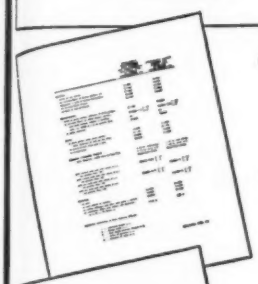
Moderator:
EDWARD L. COCHRANE, '20, *Vice President for Industrial and Governmental Relations, M.I.T.*

Alumni Luncheon
Du Pont Court, M.I.T.

Alumni Banquet
Hotel Statler, Boston

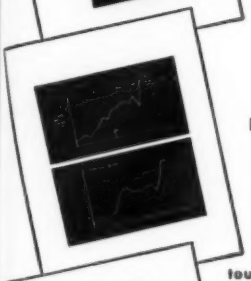


60 fully documented case histories

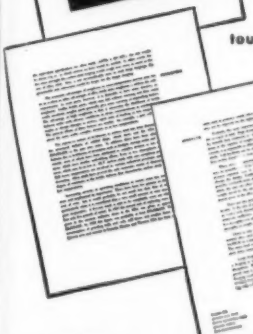


Facts on maximum pay load

Facts on lower operating costs



Facts on lower corrosion rate



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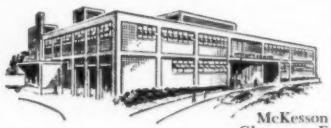
THE TABULAR VIEW

(*Concluded from page 322*)

engineering and construction interests since 1942, Mr. Finnie is author of several books and innumerable magazine articles on construction projects. He has photographed, written, and produced more than a dozen documentary sound-and-color films on major construction projects at home and abroad. His article in this issue is an adaptation of the commentary for his film "Iron Ore from Cerro Bolivar." Mr. Finnie is well known to Review readers for his articles "American Technology in Arabian Oil Lands" (December, 1951) and "Alaska and the Engineer" (June, 1945).

Textile Tycoon. — Historians generally consider the factory system in this country to have had its origin in December, 1790, when the cotton spinning mill of Almy, Brown, and Slater went into operation beside Pawtucket Falls, Pawtucket, R.I. The mill was, in very large measure, the product of the perseverance, energy, and engineering skill of Samuel Slater who, after having served as apprentice in English cotton factories (where Richard Arkwright's spinning machines were used) came to this country at the age of 21 and established himself as pioneer in the textile industry. The part which Samuel Slater assumed in building up New England's textile industry is ably told in the article "The Genius of Samuel Slater" (page 333) by E. H. CAMERON, '13, frequent contributor to The Review on items of historical technology. It will interest Review readers to be reminded that M.I.T. has its Slater Textile Laboratory named for this distinguished textile tycoon. It is also interesting to learn that the Old Slater Mill in Pawtucket is to be opened this year as a museum of textile technology. Finally, Review readers may anticipate, in the undesignated future, a book on the life of Samuel Slater – manuscript of which is being prepared by Mr. Cameron.



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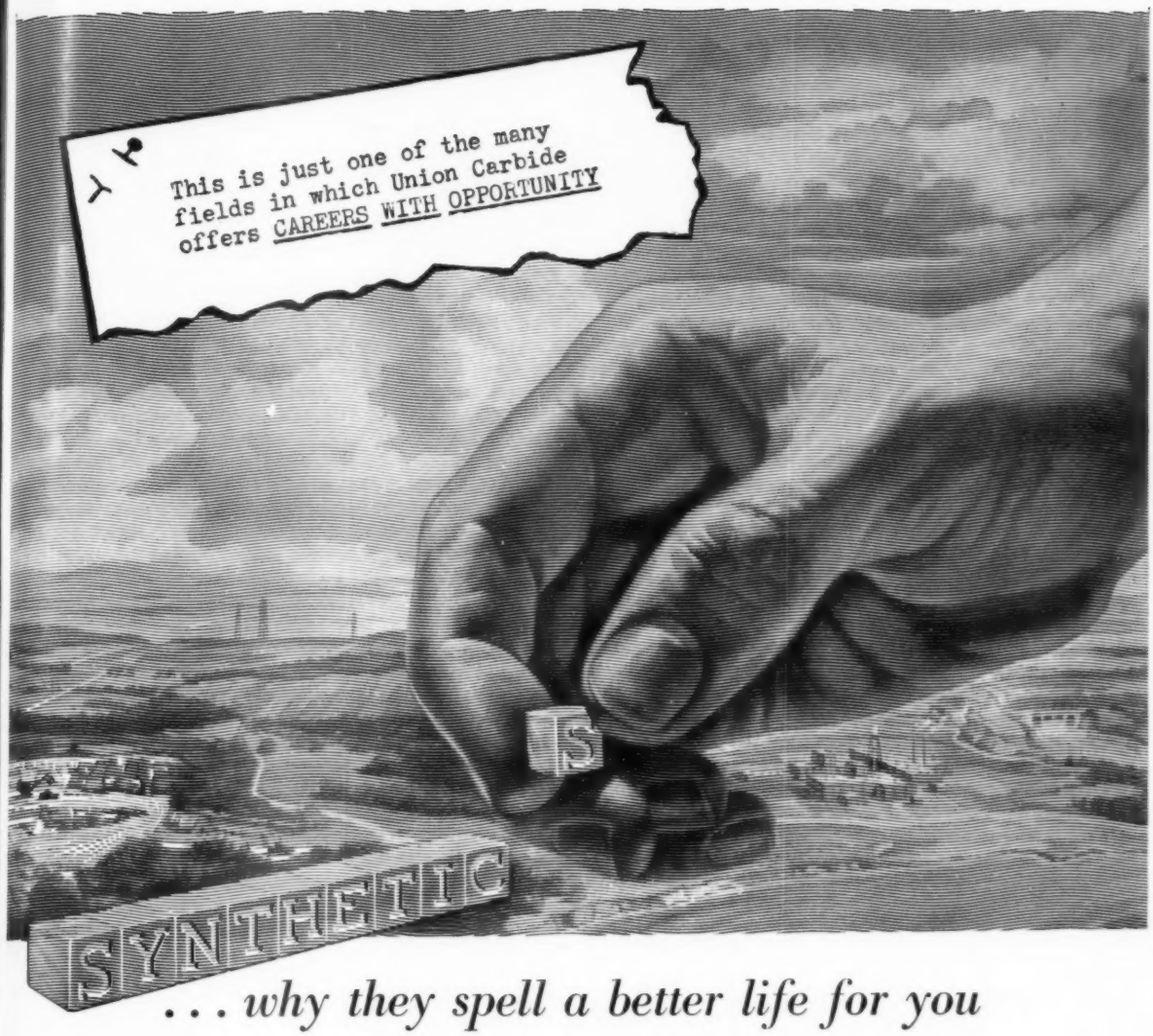

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VOL. 57, NO. 7 **MAY, 1955**

CONTENTS

JEFFERSON MEMORIAL, WASHINGTON, D. C.
PHOTOGRAPH BY RAYMOND E. HANSON ..... THE COVER

MOORLANDS, ROCK HARBOR, ORLEANS, MASSACHUSETTS
PHOTOGRAPH BY RAYMOND E. HANSON ..... FRONTISPIECE 328

THE GENIUS OF SAMUEL SLATER ..... BY E. H. CAMERON 333
The talents and initiative of a British born textile worker came to flower in the United States as Slater mills first sprang up in New England more than a century ago

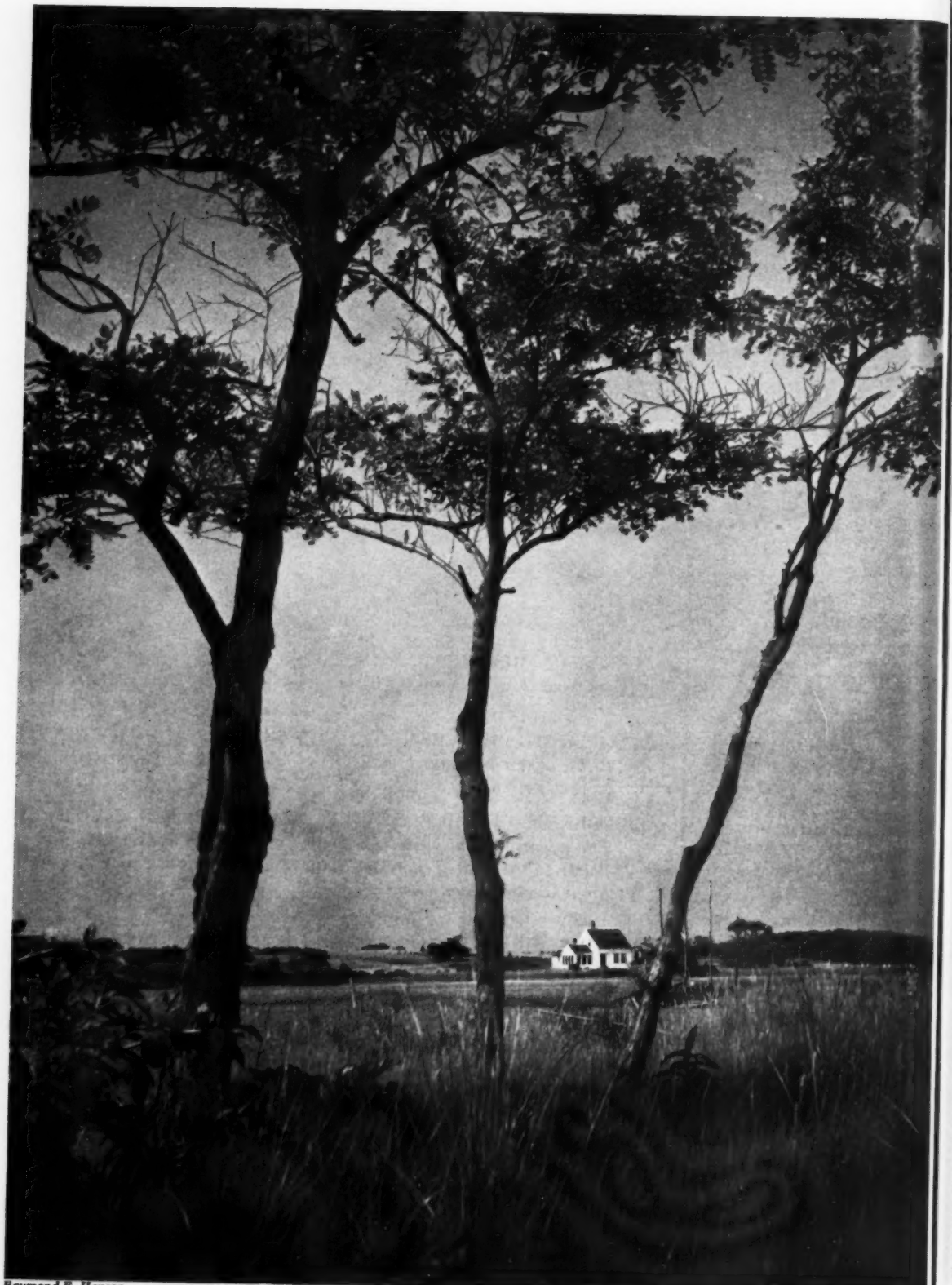
IRON ORE FROM CERRO BOLIVAR ..... BY RICHARD FINNIE 339
Iron is where you find it, but it often takes a great deal of engineering talent, construction, and administrative ability to get it where you need it

FOOD OF OUR COLONIAL FOREFATHERS
BY HARRY W. VON LOESECKE 343
Although sometimes plagued by hunger and crop failures, the colonists thrived on their limited diet and would have stood aghast at the idea of a price-support program for farmers

THE TABULAR VIEW · *Contributors and Contributions* 322

THE TREND OF AFFAIRS · *News of Science and Engineering* .. 329

THE INSTITUTE GAZETTE · *Relating to the Massachusetts Institute of Technology* 347



Raymond E. Hanson

Moorlands — Rock Harbor, Orleans, Massachusetts

THE
TECHNOLOGY REVIEW

Vol. 57, No. 7 May, 1955

The Trend of Affairs

Sedulous Ape

Now that a simian performer named J. Fred Muggs is a leading television star, the time has come for reassessment of the cultural potentialities of the anthropoid apes. Rather than comparing the intellect of Mr. Muggs with that of his fellow artists (lest the results be invidious to human beings) let us consider the attainments of a chimpanzee in private life – one Viki, who from her birth until an age of over six years lived in Florida with two scientists who were husband and wife. For the purposes of a behavior study, these people undertook to nurture the ape as much as possible like a human youngster.

At the age of six, Viki is reported to have employed a primitive form of speech, consisting of six clearly differentiated sounds, made entirely with her mouth, without use of the lungs or larynx. (Speech sounds of this nature are said to occur among primitive peoples.) Viki mastered meanings assigned to these sounds by her human guardians, not by herself. She employed this speech only to attain her needs or wants in the way of food, drink, comfort, or amusement. Speech was, however, a measure of last resort for Viki, because if possible she gained her ends silently, by leading someone to the necessary place and demonstrating what she wanted – either by handling objects or by guiding the human hand into the action she wanted performed. If these measures were unavailing, and if her desire happened to be one of the six that had been assigned to her limited speech sounds, the chimpanzee then finally expressed herself orally.

Thus Viki engaged in social activity to the extent that she enlisted the aid of human beings to do things she was unable to do, was afraid to do, or was forbidden to do. She respected authority by refraining from forbidden actions; but did not hesitate to get human beings to do things she was forbidden to do herself.

This chimpanzee also employed symbolism of a crude sort. For example, whenever her preceptors took her for an automobile ride before she was housebroken, they brought along a supply of diapers. This practice led Viki to develop, on her own initiative, the bringing of a handful of diapers as an indication that she wanted a ride. Later on, after she was housebroken and diapers were no longer kept around, she substituted the fetching of some paper facial tissues as expression of the desire for an automobile trip.

Viki was able to stand and to walk upright, and to carry heavy burdens clasped in her forelegs short distances while walking on her hind legs. She employed a variety of tools, such as spoons and pliers, and had no trouble working the lighter she used to light the cigarettes of which she was fond.

Viki's passion for tobacco brings us to what is perhaps the salient observation of this study. While smoking, the ape grasped her cigarettes delicately between the tips of thumb and forefinger. The ability to hold objects in this fashion, called "the opposable thumb" has been held by some anthropologists to be anatomically unique to the human being, and indeed to be a prime point of differentiation between man and the higher apes. The opposable thumb has in fact been considered to be the basis for the human use of delicate tools, including writing implements, and thus to be the foundation for mankind's climb up the developmental ladder. Viki's manual skills tend to negate these concepts.

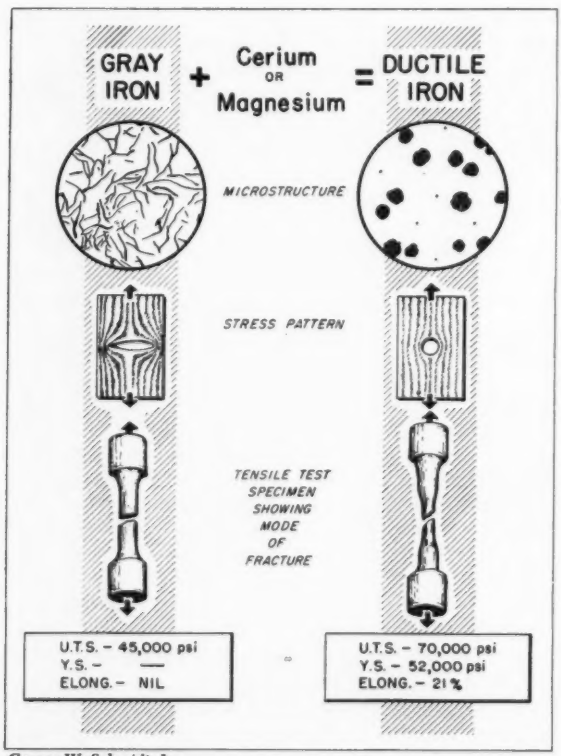
Further doubt that the opposable thumb is a valid dividing line between men and apes comes from photographically recorded observations of Balinese children and adults by the anthropologists Mead and Macgregor. These pictures show that Balinese chil-

dren during the first several years of life do not use their thumbs in opposition to their forefingers. (American children usually develop this skill by the age of one year.) Thus when the Balinese youngsters grasp an object the thumb may either be nonfunctional, or else fall on the same side of the object as the remaining fingers. Although the Balinese in time learn to employ opposed tips of thumb and forefinger, even as adults they tend to use the entire hand in manipulations, and never come to depend upon the opposable thumb as Americans do.

Thus it appears from observations of both apes and men that the opposable thumb, and the delicate manipulations it makes possible, are cultural attainments rather than inherent anatomical characteristics. Therefore it might be possible to train higher apes to have substantial manual skills. If apes continue to flourish as television entertainers, perhaps they may in time be able to endorse their own salary checks.

Ductile Cast Iron

CAST iron is an interesting member of the family of casting alloys. Although an unglamorous stepchild in the family of cast metals, it is rivaled only by wrought steel in the tonnages used annually. In spite of such wide use it is too glass-like and brittle for strategic military use or critical peacetime engineering application. Seemingly, cast iron appears to be the simplest of the ferrous metals to make, but in reality it is metallurgically the most complex. It is both the least expensive of all casting alloys and potentially the most versatile.



George W. Schmidt, Jr.

Small quantities of cerium or magnesium, added to gray iron, produce dramatic changes in its properties.

Relatively neglected in the research laboratories of America for hundreds of years, cast iron is finally commanding the interest due its venerable ancestry. This increased interest comes about because it is now possible to convert the brittle, gray cast iron to ductile iron with mechanical properties rivaling those of steels. This striking metallurgical development is new and a full appraisal is impossible to make at the present time. This appraisal is part of the job undertaken by the M.I.T. Metals Processing Laboratory during the last five years.

The engineer has long recognized that the platelike flakes of graphite in ordinary gray iron limited its strength and caused its innate brittleness. Thus he has sought a means for causing the graphite to assume a more favorable form. Invention of "blackheart malleable iron" (in which the graphite forms rosette-like nodules less damaging to ductility than flakes) was a step in this direction. Production of malleable iron requires a base metal of relatively limited composition and a very lengthy heat treatment; also, malleable iron castings are limited to use for castings of relatively small sizes and thin sections. The engineer dreamed of an iron whose structure contained spheres rather than flakes of graphite; he preferred an iron that would form the spheres during freezing, or with a simple, short heat treatment.

In 1948, the dream came true when English and American metallurgists disclosed simultaneously the means for making "spherulitic" or "ductile" iron by two different processes. The British technique involved treatment of low-sulphur, hyper-eutectic iron with cerium (misch metal); the American development employed magnesium for treating either hypo- or hyper-eutectic irons. Properly applied under favorable (but commercially practical) conditions, each process transformed the flakes of ordinary gray iron into spherulites. This amazing result was obtained as if by magic with essentially only a pinch of cerium or magnesium. Even though magnesium boils at the temperature of molten iron, it was only necessary to find a technique for retaining from 0.02 to 0.10 of 1 per cent magnesium to do the job.

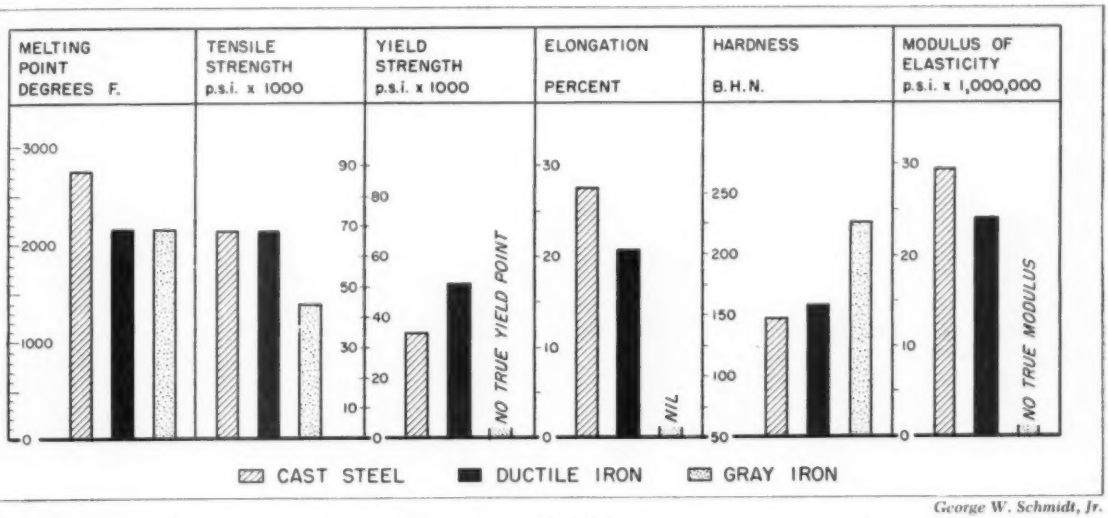
In 1950, M.I.T. and the Watertown Arsenal realized the potential technological use of ductile iron was great and that a completely adequate basic understanding of its properties was lacking. Accordingly, research was initiated to assess the potentialities of ductile irons by developing an understanding of the range of properties producible with different compositions and different metallurgical structures. One aim of such research was to enable the Army and industry to best produce and utilize this new engineering tool. Research work at M.I.T. has been conducted by Charles C. Reynolds, '47, and Howard F. Taylor, 2–46, Professor of Metallurgy.

Work has been completed on many of the engineering phases of the investigation and current work of this type centers on problems of solidification shrinkage and risering. Research is being done continuously on the more scientifically interesting problems, such as mechanism of formation of graphite in flake and spherulitic irons, primarily as thesis sub-

jects by candidates for master of science and doctor's degrees.

Work completed to date permits some tentative conclusions to be made of possible interest in assessing the future position of ductile iron in the family of cast ferrous alloys: (1) ductile iron can be made dependably in all types of melting units normally used for melting gray iron (including the induction furnace), and control of processing variables is commercially fully practical; (2) compared to gray iron, ductile iron has far superior strength, ductility, and toughness, twice the modulus of elasticity, better machinability for equal hardness, and equal fluidity; (3) compared to cast steel, ductile iron is cheaper, can be made in thinner, more intricate shapes, is easier to melt and handle, gives better surface finish, is partially "self-feeding" during solidification (if composition is controlled), has greater flexibility of heat treatment, and machines much better. Ductile iron can be transformed from a soft, ferritic matrix to one of hard pearlite or very hard martensite (and vice versa at will by suitable heat treatment) because the carbon can be precipitated or dissolved, and when precipitated is in a spheroidal form.

Will ductile iron replace other metals? This question is one which interests the producer, consumer, and investor. Ductile iron should find its own level as a dependable engineering material; it will replace some metals, of course, where greater strengths and ductilities are required than can be obtained with gray or malleable irons, and where less ductility is needed than in cast steels. Currently, gray irons are somewhat cheaper, cast steels are somewhat tougher than ductile irons, and malleable iron reigns supreme for certain applications. It will probably still be some time before ductile iron earns its industrial spurs for, like good wine, it seems to be necessary that it age before being fully appreciated.



George W. Schmidt, Jr.

Shown above are six important properties of ductile iron, graphically portrayed in comparison to those of cast steel and gray iron.

Range of Microwaves Extended

DIRECT television and multi-channel telephone transmission through space for as much as 200 miles, without relay stations and at ultra-high frequencies, has been accomplished, Bell Telephone Laboratories and M.I.T. announced late in March. Television pictures, as well as radio and telephone conversations can be sent over the horizon on ultra-high frequencies, in an extension of a transmission technique applied to the continental defense system.

Principal virtue of over-the-horizon transmission is that longer communications bridges are possible over water and rugged terrain. In the present microwave radio relay network across the United States, relay stations are 30 miles apart.

Standard amplitude-modulated radio broadcasting employs waves that follow the earth's curvature. But waves used in television and telephone relays were presumed to travel in a straight line. For many years, "line-of-sight" transmission between antennas placed on towers on the horizon (about 30 miles apart) was thought to be the only practical means of transmitting by radio the wide bands needed for television and multi-channel telephone service.

This was disproved after years of research at M.I.T. and the Bell Telephone Laboratories. The Bell Laboratories' research stemmed from Bell's success with transcontinental microwave systems for carrying telephone conversations, radio and television programs from coast to coast and their continued interest in radio propagation. The M.I.T. interest was stimulated by work for the government in radar and overseas broadcasting.

Scientists knew that ultra-high frequencies traveled over the horizon under certain conditions, but believed them to be too weak and undependable for practical use. In the course of investigating occasional interference attributed to these waves, however, the scientists discovered that many actually overshot the relay towers they were aimed at, and arrived at farther points with remarkable consistency.

The next step was to provide reliable long-distance transmission over the horizon. M.I.T. and Bell Lab-

oratories engineers did this by erecting larger antennas and using higher power than is employed in the conventional microwave system. Thus, they put to use the weaker signals that drop off a straight radio beam beyond the horizon and are reflected or scattered to distant points by the atmosphere.

The effect of the new system is very much like that of a powerful searchlight, which casts a beam in a straight line. A searchlight aimed at the sky can be seen from the ground miles away, even when the searchlight is behind a hill. This is possible because some of the light is reflected to the ground by the atmosphere.

Even after scientists learned that transmission was possible over the horizon, they were not certain that this medium would support the broad band of frequencies needed for multi-channel telephone or television transmission. In the fall of 1953, they found that they could transmit 12 voice channels over the horizon.

Television was first successfully transmitted over the horizon in 1954 between the Holmdel, N.J., laboratory of the Bell Telephone Laboratories and the M.I.T. Round Hill Research Station near New Bedford, Mass., a distance of 188 miles. Bell and M.I.T. scientists emphasize that this success with over-the-horizon transmission will probably result in a supplement to, rather than a replacement of, line-of-sight radio relay systems.

Over-the-horizon signals are not to be confused with a similar type of transmission known as "ionospheric scatter," which is useful in long-distance transmission of telegraph signals at relatively low frequencies. Unlike ionospheric signals, the over-the-horizon technique provides signals that are useful for the wide band widths required for a television picture or by many telephone channels.

Disposal Proposal

A MAJOR problem created by the concentration of vast numbers of people in urban residential areas is the disposal of wastes – sewage, trash, and garbage. Sewage disposal as a rule can be accomplished satisfactorily, by means of modern sewerage systems and sewage treatment methods. Nondecomposable trash, if collected separately from garbage, may be burned when combustible, otherwise used as land fill. Getting rid of garbage – putrescible organic household refuse – is the biggest difficulty. Garbage can be burned; but incinerators and their operation are costly, and apt to pollute the air.

For a while the "sanitary land fill" was thought to hold great promise for municipal garbage disposal. This procedure involves using garbage to fill in swamps, or other low-level land, for reclamation purposes, and keeping the top surface of the refuse covered with clean earth. But a serious weakness has developed at the "working surface," the exposed strip of recently dumped garbage. The inevitable occurrence of fires, stenches, and insect and rodent nuisances at the working surface have militated against wide adoption of the sanitary land fill.

A procedure long used abroad, but only recently tried in the United States, is the composting of garbage. Composting in its basic sense is familiar to farmers, and even to suburban gardeners. Suburbanites, for example, often accumulate grass cuttings and fallen leaves in a compost heap and then, after decomposition is complete, use the resultant material for fertilizer.

Experience in Europe, Asia, and South Africa has demonstrated that domestic garbage can be successfully composted by itself on a large scale. It is necessary first to grind coarsely or shred the garbage, employing a hammer mill or any other machine that will break up the refuse without pulping it. The ground garbage is stacked in windrows, on the ground out of doors; then is periodically aerated by turning about twice a week with spades or forks.

Garbage composting is reported to be quite free of unpleasant odors, provided the heaps are well aerated. The characteristic sour odor of the garbage disappears as soon as it is ground. During the first three or four days of composting there is a faint "cooking" odor, followed by a slight musty or earthy odor, followed finally by complete disappearance of odor when composting is complete. The color of the refuse at first is the grayish-green of freshly ground garbage; this gradually turns to the dark brownish-gray typical of compost made from whatever material.

The progress of composting may thus be followed by gross observations of color changes. Internal temperatures of the heaps are also a clue; these temperatures first rise to about 75 degrees C. within a few days, then gradually fall to about 55 degrees C. at the end of two or three weeks. Then decomposition is complete and no further rotting can ensue. The end point of composting may be verified by chemical analysis for carbon and nitrogen. When a carbon to nitrogen ratio of 20 to one has been reached, composting is complete and the compost may be used on agricultural soils without "robbing" nitrogen.

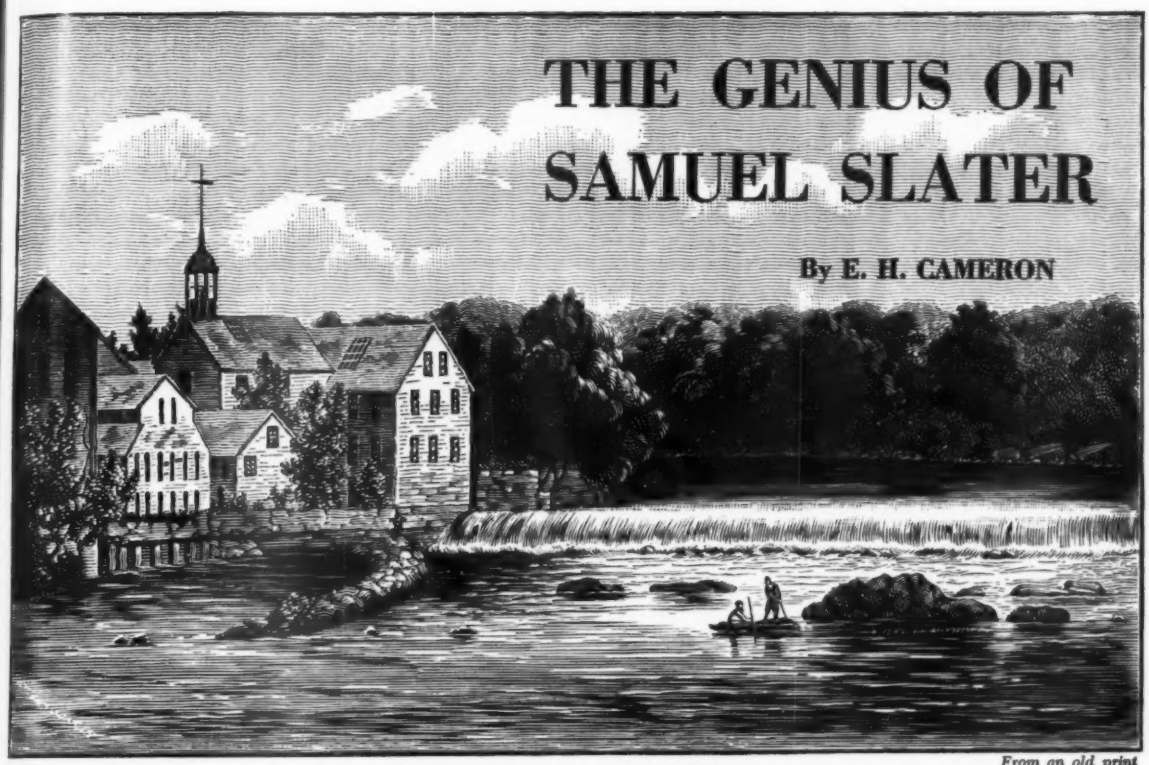
As a fertilizer, compost made from domestic garbage provides nitrogen, phosphorus, potassium, and trace elements to promote plant growth. Aside from its chemical values, such compost is beneficial to agricultural soils by improving their physical texture, increasing water retention, and fostering development of extensive root systems.

Proposed use of compost from domestic garbage, as a fertilizer in the growing of foods, brings to mind the serious disease transmission caused by use of human excreta for fertilizer in the Orient. Therefore, it is reassuring to learn that the sustained high temperatures spontaneously generated by composting reliably kill all common disease germs and parasites.

Thus the composting of domestic garbage converts a foul offensive waste into a stable valuable fertilizer. The process does not cause odor, insect, or rodent nuisances. It is safe from the public health standpoint. But whether garbage composting will ever find wide adoption by United States cities depends upon local climates, and also upon financial considerations such as costs of segregating decomposable organic garbage from nonputrescible trash, expense of the composting process, and economics of the storage, distribution, and use as fertilizer of the resulting compost.

THE GENIUS OF SAMUEL SLATER

By E. H. CAMERON



From an old print

View of the Old Slater Mill in 1840

When the Old Slater Mill, in Pawtucket, R.I., opens its doors to the public as a museum of the early textile industry, many people will be attracted to view its exhibits. These will include not only textile men, but also the general public, with its appetite for history, Americana, and the moving wheels of machines. Those engaged in textile manufacturing will not have to be told that the Old Slater Mill, built in 1793, is the shrine of the American cotton textile industry. Displayed before all visitors will be authentic evidence of the genius of Samuel Slater, who introduced to America the equipment and factory processes that started our textile industry on its way to success.

DURING the period of the American Revolution, whereby the 13 Colonies became independent of England, another revolution was under way within the confines of England itself. This was the industrial revolution; which has been called "probably the greatest evolution in human history."* The factory methods that it developed were made to order for the industrially impoverished, young United States of America. In the United States, as in England, the textile industry led the way in the application of these factory methods.†

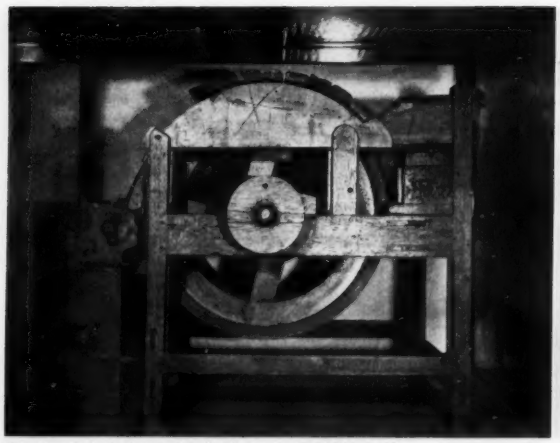
The story of the introduction of these novel methods in America by Samuel Slater has become an inspiring saga among textile men, for it was the genesis of the great industrial system that now leads the world in its production processes. The Slater story is in three parts. The first part reviews the events of the industrial revolution in its early English phases, and tells of the apprenticeship of Slater, whereby he learned to build, install, and operate the newly invented equipment for the preparation of cotton and the spinning of cotton yarn by machines. The second part describes his remarkable duplication of the English machines in Rhode Island, which he installed and operated in the first successful cotton mill in America. The third part is the account of his creation of the widespread Slater establishment that became such an important factor in early American textile development during the first third of the Nineteenth Century.

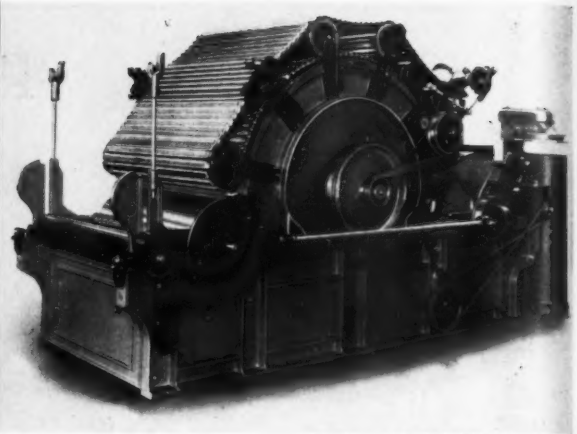
Industrial Revolution

At the time of the birth of Samuel Slater (June 9, 1768) the early stages of the invention of machine methods for the carding and spinning of yarn were under way. The crude models were made with timber frames, wooden cogwheels, and had very few parts of metal. Yet they gave promise of success in simulating the deft touch of human fingers and the precise timing of muscular effort that our ancestors had performed since prehistoric time, as they spun yarn for their clothing. The clever English mechanics who made these crude models did not realize that they had started the industrial revolution, with its factory system upon which our modern industrial economy is based. The period of

*Roger Burlingame, *March of the Iron Men*, page 91 (New York: Charles Scribner's Sons, 1949).

†*Historians' History of the World*, XXI: 484 (New York: The Outlook Company. London: The History Association, 1904).





Courtesy of U.S. National Museum (Smithsonian) *Courtesy of Whitin Machine Works*

Contrasting the old and the new, at left may be viewed the Samuel Slater Carding Machine of 1790, and, at right, one of the modern cotton cards.

inventive activity continued, and as more successful machines were developed, a novel establishment was created – the factory. Factories were huge places for the quantity production of goods by machine. These were soon to replace the numerous home shops where goods in small, individual quantities, but of immense aggregate volume, had been made by hand for generations—in the villages and on the farms of the thriving handicraft textile centers of England.

Historians define the three major factors that caused the industrial revolution as: the invention of textile machinery; the invention of the Watt steam engine; and the discovery that iron ore could be smelted by the use of coke.

The machines of the early factories were driven by water wheels. Thus, the factories were located in the rural areas, along streams where good water-power sites were to be found. When it became increasingly difficult to recruit a sufficient supply of mill operatives to work in the rural areas, steam gave the answer, for it could supply power, miles from any water-power site. Huge, steam-driven factories therefore rose in Manchester and other English cities, where labor was plentiful. With the discovery that they could substitute coke for the charcoal derived from the sadly depleted forests, the foundries and forges of England became able to increase their production of iron. The textile industry was a ready market, for better machines could be made from cast iron or wrought iron; wooden members could be largely dispensed with. There was the corollary stimulus toward greater accuracy in machine tool methods, which was of immense advantage to all industry: textile, iron, and the rest.

The Apprentice

Samuel Slater grew up with the industrial revolution in England. He was born a few months before Watt secured his patent for his steam engine, and one year before a patent (later annulled) was granted to Richard Arkwright for his famous spinning machine, which was called the water frame, because it was driven by water power. Distinguished names in the archives of textile history are those of the ingenious men who contributed to the ultimate success of the machine methods—Kay (flying shuttle), Wyatt, Paul, High (early spinning models), Hargreaves (spinning jenny), Crompton (mule spinner), Cartwright (power loom, years later), and Arkwright, whose unified system of carding, roving, drawing, and spinning was to achieve the greatest success. He became the great Sir Richard Arkwright, major prophet of the industrial revolution. In the place of his birth, Belper Township, Derbyshire County, Samuel Slater was to be introduced at the age of 14 to the Arkwright system of spinning yarn, which he was in turn to introduce to the struggling American cotton industry a few years later.

In 1769, Arkwright had built the world's first spinning mill at Hockley, near Nottingham Market. Here he strove to perfect his water frame that was coupled temporarily to horses as prime movers. As he needed money, he entered partnership with Jedediah Strutt, a prosperous manufacturer of ribbed stockings in Derby. The partnership was a success. In 1771 it built the world's first water-powered spinning mill at Cromford on the River Derwent, and also another mill a few miles south in Belper in 1776, which Strutt took over when the partnership was dissolved. As Strutt's activities expanded, he needed more factory help, and asked his neighbor, William Slater, a prosperous farmer and timber merchant, to apprentice his eldest son to him. The father recommended a younger son, Samuel, however. "He writes well and is good at figures," Slater explained.

Shortly thereafter, as William Slater was binding a load of hay, the rope broke and he fell backward off the wagon. He was badly hurt. When Samuel asked him to arrange for a formal indenture, he replied: "You must do that business yourself, Samuel, I have so much to do and so little time to do it." And the sturdy English yeoman, William Slater, passed away a few hours later.‡

So the boy of 14 went to the mature businessman, Strutt, and discussed the future prospects of this new industry of the machine spinning of yarn. When he received a reasonably optimistic estimate of the

‡ Derby *Mercury*, August 8 to 15, 1782.

future from Strutt, who was later to become very wealthy, Samuel Slater made his first important decision.

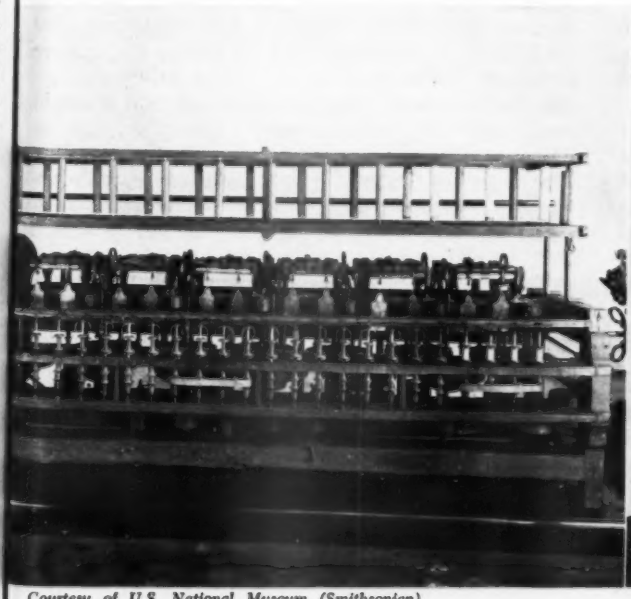
It was in the year of the ending of the American Revolution (1783) that Samuel Slater signed his indenture as an apprentice to Jedediah Strutt for six and one-half years. He was under a good master, who had been a close friend of his deceased father, William Slater. Faithfully young Slater kept to the terms of his indenture to the end. Under Strutt his mechanical genius was developed, and his ability to manage others was recognized by his employer when Strutt finally put him in charge of still further new factory activities.

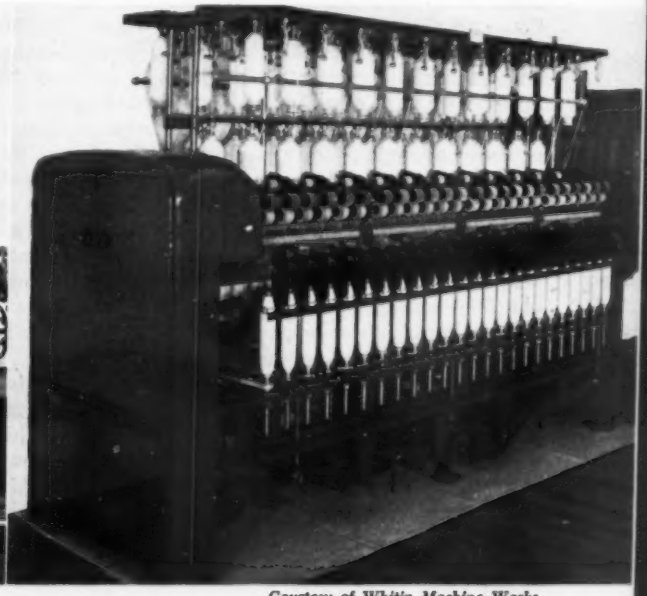
As the termination of his indenture approached, young Slater faced another and still more important decision — what to do next. In the making of this decision he asked no advice. Even in that day of limited communications, the news reached Derbyshire that certain American organizations had advertised for men who could build the Arkwright spinning equipment. Slater also knew of the rigid English restrictions on the emigration of trained mechanics or of those who would carry models or drawings of these precious machines that were making many Englishmen prosperous. The emigration of farm laborers was not forbidden. What tall, young man of an engaging presence knew more about the Arkwright system than Samuel Slater? What man could better keep his plans to himself, even to the extent of not informing his own mother that he was planning to go to America? English records indicate that Slater was a typical emigrant of his day. The ill-conceived English laws did not stop any resolute mechanic from going to America, despite them. Reputedly in the guise of a farm laborer, Slater embarked from London, and after a 66-day voyage arrived in New York in November, 1789, at the age of 21. This was the year when the American colonies became the United States of America, with the adoption of its constitution.

The First Mill

The American need for men like Slater, who knew the manufacturing processes, was acute. America was an agricultural country; 95 per cent of its population resided in rural regions. Although it also had a flourishing commerce and a valuable fishery trade, it was pitifully poor as regards manufacturing industry. With few exceptions, its manufacture was limited to handmade goods, produced for use by those who resided in the homes in which they were made. Farseeing statesmen and men of business realized the industrial needs of the young American republic, and took steps to promote industry here. Their efforts concentrated on the securing of information on the new and highly successful English textile machines for the spinning of yarn. (A quarter of a century was to elapse before a practical power loom was perfected.) As regards clothing, every New England home was a textile factory that spun its home-grown flax and reared its own sheep for wool, which was woven with the flax into the rough, yet warm linsey-woolsey for family raiment. The great natural resources of America lay fallow, because of the lack of manufacturing methods to develop them.

Samuel Slater was to begin to realize this condition when he went to the New York Manufacturing Company upon his arrival in America to ask for a job. He was disappointed to find that their antiquated machines were not "worth using." Captain Curry, a newly made friend of Slater's in New York, advised him to see next a wealthy Providence Quaker named Moses Brown, whose firm, Almy and Brown, was concerned in a textile venture and needed help. His businesslike letter to Brown re-





Courtesy of U.S. National Museum (Smithsonian) *Courtesy of Whitin Machine Works*

(Right) *Modern cotton spinning frame, used for experimental work, selected for comparison with Slater frame* (left). *Modern spinning frames, used in production, are about five times as long as that shown at the right.*

White's Memoir of Samuel Slater

Pawtucket in the 1830's. The belfry of the Old Slater Mill appears just above the bridge on the left bank of the Blackstone River.

sulted in an invitation for Slater to visit him and the promise of a generous share of the profits if Slater could succeed in making the heterogeneous collection of spinning machines, that Brown had assembled, produce yarn of a satisfactory quality.

Arriving in Providence, Slater was sent to Pawtucket, where the Brown machines had been set up. He examined them and pronounced them worthless. They were typical of the several American imitations of the Arkwright machines, which despite state aid in Massachusetts, bonuses in Pennsylvania, and similar inducements elsewhere, still failed to make good yarn at all, or at best, yielded no profit.

Impressed with the evident knowledge of Slater of the construction and operation of the Arkwright machines in England, shrewd Moses Brown gambled on the ability of the young English immigrant to reproduce them. In the partnership agreement of a new firm, Almy, Brown & Slater, the new partner was to construct and operate the Arkwright machines at a wage of $1.00 per day. Almy and Brown were to supply the money, market the finished product, and give Slater one-half the net profits.

An inspiring story in the annals of American industry is the account of Slater's success. By a remarkable feat of memory, supplemented by his unusual mechanical ability, with no models or drawings to guide him, this youth of 21 produced, within a few months, equipment that performed the delicate processes required to transform raw cotton into finished yarn of superior quality. His master, Strutt, could attest to this fact when he examined sample yarn that his former apprentice had proudly sent him. In this accomplishment, he was assisted by Sylvanus Brown, a noted worker in wood, and David Wilkinson, who was skilled in the shaping of iron.

It was wholly a handmade job, made mostly of wooden members, like the original English models. On the floor of the little woodworking shop of Sylvanus Brown in Pawtucket, Slater sketched the frameworks in chalk, according to one account. Brown cut them out of good oak and fastened them together with wooden dowels. The many oak spindles were turned and fitted with iron shafts, threaded by Wilkinson. He also turned the rollers which were the most important members of the Arkwright system. Each bottom roller was milled, so that it would firmly grip the leather-wrapped top roller, thus to draw out the yarn on its progress to the spindles. The "carding engines" were made of wood practically throughout, with the exception of the hundreds of tiny iron teeth and the leather in which they were inserted.

The mature mechanics, Brown and Wilkinson, accepted the opinions of young Slater, as he recalled each detail of the Arkwright machines and told them how to reproduce them. He had to keep ahead of these mechanics. He made sketches, devised special tools to build the unusual members, and inspected the finished ones. We may believe the old account that said that he worked day and night. Their accomplishment may be studied today, for one of their "carding engines" and a water frame are now on exhibit in the National Museum (Smithsonian) in Washington.

To those who know its story, the Slater-built Arkwright machines are among the most inspiring exhibits at Smithsonian. Like the early textile equip-

ment in English museums, they are crude, and their working elements are far short of the smoothly efficient functional arrangements by which modern equipment spins cotton into yarn to today's high standards. Yet it was the best American spinning gear of the time, and it made good yarn.

The carding engines, water-frame spinners, and auxiliary equipment were set up in Carpenter's Clothier's Shop in Pawtucket, which was driven by a water wheel fed by the Blackstone River. The machines were soon producing so much yarn that its marketers, Almy and Brown, were swamping the market. This is easy to understand, for Slater's first two water frames had 24 and 48 spindles. They were in continuous operation, as compared with the single-spindle, hand-spinning wheels that were operated in the local farmhouses, and that had supplied the demand for yarn up to that date.

This first cotton mill in America successfully to use the Arkwright machines started operations on December 20, 1790. It was the year of our first census, which reported the American cotton crop as 3,000 bales, as compared with 1,062,000 bales in the year of the death of Samuel Slater (1835). When the accounts of Almy, Brown & Slater were squared two years later, Slater's share of the profits was computed to be more than £400. Added to his wages, this represented a handsome income for a man of 24, in this year of 1792.

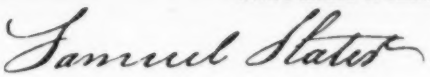
Except for the supervisor, Samuel Slater, only children worked in Slater's first American mill, at the start. At the end of three weeks, it had seven boys and two girls, whose ages ranged from seven to 12 years. They operated the new machines, under the strict supervision of young Slater, who had the reputation of being a strict disciplinarian, although scrupulously fair. In America and England it was decidedly the day of child labor. The children were used to this. In this period of scant power equipment the efforts of many hands were required, and many tasks could be performed by children's tiny hands.

Gradually a market for so much machine-spun yarn was developed; first, by "putting it out" to the local homes for hand weaving, or by selling the yarn outright. Ultimately, Almy, Brown & Slater yarn could be purchased from agents located from Portland, Maine, to Charleston, S. C. Long before this wider market was established, the demand had outgrown the capacity of the equipment of small Carpenter's Clothier's Shop. Like the proprietors of all small, successful ventures, the firm decided to expand. They built what is now the Old Slater Mill, and started operation there in 1793.

The Old Slater Mill

A timber dam was built about 20 rods upstream of the 60-year-old dam at Carpenter's Clothier's Shop; an intake above the new dam led the water to a narrow millpond, from which a flume led to the single water wheel at the mill. The mill was 44 feet long, 30 feet wide, and had 2½ stories. It was built much like a New England barn, with vertical sideboards, nailed to horizontal, hewn timber members at top and bottom. Unlike a barn, the mill had

White's Memoir of Samuel Slater



clapboards and was plastered and whitewashed inside. It was heated by stoves, and before sunrise and after twilight was lighted by candles. (It is possible that some oil lamps were also used.) The mill had a bell tower and a bell that weighed 60 pounds. Whether they slept in feather beds or on cornhusk mattresses, the bell warned the juvenile and adult operatives when to arise and go to work.

As the bales of raw cotton, then averaging 225 pounds in weight, were received at the mill, portions of the cotton were sent out to the various homes in the vicinity where it was cleaned on flakes. These consisted of cord screens that would let through the motes, hulls, or other trash, when beaten with willow switches by the women. The cleaned bunting was returned to the mills to be spun into yarn. On the grassy area about the mill, women and children then spread the yarn, praying for days of long continued sunshine. Kept wet by frequent sprinkling by watering pots, the yarn would bleach under the action of the sun and air in a period of about four weeks. The yarn would then be sent back to the local homes to be handwoven into cloth and returned to the mill for dyeing and finishing. Several years would elapse before all these processings of the raw cotton into fabric were to be carried on under the one roof of a cotton mill.

This pioneer cotton mill development was typical of the many textile mills that were to appear along the New England rivers within a few decades, on sites where a good flow of water could be expected for most of the year, and where a dam of suitable height could be constructed. Several such mills were

built by Slater, many by competitors who were inspired by his success. More than one was built by those who had learned the methods of spinning in a Slater mill. Historians of the American textile industry emphasize the part played by Slater as a teacher of the Arkwright processes. In particular, the Blackstone River became known as the hardest working little river in the world. An ample supply of American cotton was soon to be assured by the invention of the cotton gin, which was invented by Eli Whitney in the year of the building of the Old Slater Mill (1793), and patented a year later.§

More Mills

The success of the Old Slater Mill led to his next American venture, as equipment was improved and the market for cotton yarn was developed. In his early thirties, Slater had so impressed others with his mechanical genius, operating ability, and sound financial judgment that he was able to promote the building of the "White Mill," at the easterly end of the upper dam. It was operated by a new firm: Samuel Slater & Company. As his activities continued to expand, Slater called upon a younger brother, John Slater, to come to his assistance. John was a millwright in England, who was experienced in the operation of the Crompton mule spinner, then recently invented. A pack-horse trail exploration of the northerly wilderness along the Blackstone River by John Slater led to the selection of the site of the next Samuel Slater cotton mill development. It was on the Branch River, a tributary of the Blackstone, in Smithfield. Here, dam, mill, and cottages for the operatives were built and the village was named Slatersville, in 1806.

Learning of the water-power advantages of mill-sites in Oxford, Mass., shortly before the War of 1812, Samuel Slater started and developed an extensive textile establishment there, which continued to be one of his major activities until his death. This became the town of Webster in the year 1832. He also promoted the Providence Steam Cotton Company – one of the first cotton mills to be powered by steam in America.

When they ran into financial difficulties, the proprietors of a tiny mill, located at a point on the Merrimack River in New Hampshire, asked Samuel Slater for a loan, about 1816. Slater drove to the site in his chaise, and was greatly impressed with its superb water-power possibilities. He was active in the development of this enterprise.|| The mill was enlarged, new equipment added, and the growing enterprise became prosperous. It was under his management that it became the Amoskeag Manufacturing Company, in Manchester, which in its heyday, years after his death, had 728,000 spindles and 24,000 looms, which turned out cloth at the rate of more than a mile a minute. Up to his death, Slater continued as a stockholder in Amoskeag.

§Jeannette Mirsky and Allan Nevins, *The World of Eli Whitney*, page 68 (New York: The Macmillan Company, 1952).

||William P. Straw, *Amoskeag in New Hampshire*, page 10 (New York: The Newcomen Society of England, American Branch, 1948).

Samuel Slater & Sons

There were other Slater ventures, located in Massachusetts, Rhode Island, and Connecticut, nearly all of which were promoted and organized under partnership arrangements by Slater himself. His major partners were relatives of the talented family of his first wife, Hannah Wilkinson; his brother John; and his sons, whom he had trained to the methods of mill operation that he had found successful. Toward the end of his life, he established the partnership of Samuel Slater & Sons. While he had provided for the proper education of his sons, he put them to work in his mills in their very early teens; business and education went on simultaneously for one or another of them. He assigned heavy responsibilities to his sons, and while still young men, they carried on and expanded the Slater textile estate successfully after his death.

The file of letters between father and sons and from son to son, provides a heartening revelation of an admirable family relationship. Business problems and the care of their own health were discussed in his letters to them, spiced with a dry humor often expressed in Biblical terms.

Space does not permit a detailed description of the Slater ventures following his construction of the Old Slater Mill. They were promoted, built, and operated by the exercise of the same traits of business acumen and personal characteristics by which he had made his early ventures successful. The promotional, mechanical, and operating talents of Samuel Slater have been described. His possession of these qualities does not wholly explain his remarkable success, however; they were supplemented by personal characteristics that were of equal importance. Matching his tremendous confidence in his own abilty to accomplish his ends, was an innate quality whereby he inspired the necessary confidence in others that he could come through. The most cogent example of this Slater trait was his quick convincing of the shrewd Yankee-Quaker, Moses Brown, that he should finance Slater. At the time after the Revolution, when all Englishmen were under suspicion, the young English immigrant, Slater, so impressed Brown that he backed him with Brown dollars, that were always closely counted. A common trait of the two men was their integrity.

In later life, Slater once told a friend that he had averaged 16 hours of work a day during his first 20 years in America. We can easily believe this statement. He had to travel from one mill to another by chaise, or an occasional stagecoach. He had to write all his correspondence by hand with a goose quill pen; he had to demonstrate personally many of the processes of his mills, they were so new.

Withal, he found time for the other things of life: was a distinguished lay member of his Episcopal church; a noted philanthropist; a bank president; the man whom some accredited with the starting of the first Sunday School in America; he got pleasure from his farm.

Samuel Slater died on April 20, 1835. Two years before his death he received a tribute from a high

(Continued on page 368)

Aerial view of Cerro Bolivar, prior to construction and mining operations

Iron Ore from Cerro Bolivar

When a Mountain of Iron Is Located Deep in a Country Devoid of Modern Transportation Facilities, Great Engineering Talent Is Called for

By RICHARD FINNIE

In southeasterly Venezuela, one of the largest of the tributaries of the Orinoco is the Caroni, which flows northward from the interior. About 50 miles due south of the Orinoco and somewhat west of the Caroni stands a certain hill – 1 mile wide, 4½ miles long, and 1,800 feet high. In 1947, after two years of intensive investigation in Venezuela, geologists of United States Steel Corporation determined that this hill, whose name was changed from La Parida to Cerro Bolivar, was encrusted in iron ore.

The exploration survey which resulted in the discovery of Cerro Bolivar and adjacent iron-ore deposits was conducted under the direction of Mack C. Lake, consulting geologist and mining engineer, while F. H. Kihlstedt was the engineer who personally led the discovery group. Mack Lake was destined in January, 1950, to be the first president of Orinoco Mining Company, a U. S. Steel subsidiary formed to develop the deposits.

Supplies were brought up the hill by every available means, including tractors and burros. A churn drill was set up to plumb the ore body. Wagon drills pressed against a sheer surface to begin an exploratory tunnel, A pilot screening plant was assembled. The tunnel went deeper and deeper. The broken ore was trundled out, carload after carload.

By now the facts were known: Cerro Bolivar was capped with a thick deposit of high-grade iron ore. It contained more than 400,000,000 tons averaging about 58 per cent iron. Plans were made for production and shipment – once full production was achieved – at an initial annual rate of 5,000,000 gross tons, with provision for expansion to 10 or more million tons.

It was one thing to locate this ore body; it was quite another thing to develop it. Orinoco Mining Company proceeded to solve a major problem of logistics: first, to bring in supplies and equipment; and then to get out the ore and carry it to market. Camps had to be set up, a road and trackage had to be pushed across grassland and jungle between the hill and the Orinoco, where crushing and handling equipment – an integrated part of the mining operation – and port facilities would be needed, while a channel would have to be dredged for ore-carrying vessels.

Simplified map of Venezuela showing locations of Caracas, Ciudad Bolivar, Cerro Bolivar, Puerto Ordaz, and the Orinoco and Caroni Rivers. Navigation route to and from Puerto Ordaz and the Atlantic is through the Caño Macareo. Right: *The late Mack C. Lake, consulting geologist and engineer, in charge of exploration survey that resulted in the discovery of Cerro Bolivar.*

Early in 1952 a bulldozer crashed through the thick growth at the confluence of the Caroni and Orinoco, clearing a site for a construction camp at the future port. Thus started a long-range construction program — one of the most ambitious ever undertaken by private capital in a far country. Construction crews lived in houseboats tied up to the shore, supplemented by tents on high ground nearby. A new community was in the making — Puerto Ordaz it was named, after the first Spanish explorer who sailed up the Orinoco in 1531.

To the Puerto Ordaz waterfront early every morning came a variety of craft bringing Venezuelan workers from the town of San Felix several miles downstream. A converted L.C.T. carried about 500 of the men who were employed on the construction of the main base camp and harbor. All told, the Orinoco Project would absorb a peak force of 7,000 people, over 75 per cent of whom would be Venezuelans — on the river and overland to Cerro Bolivar, as well as at Puerto Ordaz itself.

The constructors proceeded to erect dwellings, office buildings, shops, and warehouses for the base camp. There were temporary tanks for the storage of fuel oil and gasoline, and Diesel engines and generators for a temporary power supply. Machine shops and repair shops maintained a growing list of equipment. There was two-way radio-telephone connection with Caracas as well as nearby outposts and river traffic. A landing strip was laid out for daily passenger airplane service to and from Caracas and elsewhere.

Of prime consideration was the health of all the employees, so a fully equipped and well-staffed clinic was set up to carry on until a permanent hospital was built. Water piped from the Caroni was filtered, chlorinated, and distributed for use during the construction period.

Only a few months after the beachhead had been established, Puerto Ordaz was taking on the appearance of a thriving community. Not all of the work was going on out-of-doors. Administrative people, engineers, and warehousemen spent long hours keeping abreast of their varied duties. Both men and women were employed in the offices, where reports, plans, and specifications were made out in Spanish and English, and where business was regularly conducted in the two languages.

Management meetings were held daily to insure a smooth-running organization. Officials of Orinoco Mining Company met with those of Constructora Bechtel, who were the managers of construction. The physical work on the project was being done by 30 Venezuelan contractors and several North American firms. The management group was backed by supervisors and office people, both North Americans and Venezuelans.

Every North American here was expected to act as an unofficial ambassador of good will, as well as a technician and teacher. There were only a few in relation to the total force, and each was a key man, helping new Venezuelan employees to learn new skills and improve their earning power.

In May, 1952, a strange craft appeared on the Orinoco, being towed upstream. It was the largest steel structure ever built in the form of a barge, and it came from U. S. Steel's Consolidated Western Steel Division yard at Orange, Texas, 2,500 miles away. It was 82 feet wide, 376 feet long, 15 feet deep, and weighed 2,250 tons. It was the first of three identical barges that were to be fixed end to end to form a revolutionary type of dock for the handling of cargo and the loading of ore at Puerto Ordaz.

Bulldozers and scrapers pushed and carried great quantities of fill for a shore approach. When the barge was maneuvered into its final position, a remarkable operation ensued. On the deck were carried twenty-six 100-foot lengths of steel pipe, six feet in diameter. These were to serve as caissons or piles on which the barge would eventually stand. One at a time the caissons were hoisted to a vertical position by a 100-ton-capacity crawler crane. Then they were dropped through wells on each side of the barge, in two rows of 13, until all stood on the river bottom.

The next step was to raise the barge to pier height, which had to be above flood stage – an elevation here of about 40 feet above low water. The hoisting was done by a combination of ingenious air jacks. Fitting over the circumference of each caisson and attached to the deck, the air jacks climbed the caissons much as a boy might shinny up a tree. With all the jacks operating in unison, every time their upper halves were raised six inches, the whole structure went along with them. When the barge reached its ultimate height, the big crane swung into action with a steam hammer weighing 40 tons. One at a time the jacks were released while the caissons were driven home to bedrock. After that, the projecting tops of the caissons were trimmed to deck level.

As the season advanced, the two remaining barges in succession were brought from the Gulf Coast to Puerto Ordaz. They carried on deck not only their 26 caissons apiece but also a great deal of heavy freight. When all three barges were fitted into position they became a permanent heavy-duty, all-purpose dock, 1,128 feet in length. This unique dock saved months that would have been expended for a conventional one of comparable size and strength.

The initial freight for pioneer construction had been lightered ashore; but only 11 days after the arrival of the first of the caisson barges that formed a dock, a supply ship was able to come alongside to unload. From that time on, all manner of freight, no matter how heavy or bulky, could be unloaded promptly. Before the end of the project, about 300,000 tons of material and equipment would have crossed this dock. Not only were pieces of heavy construction equipment coming ashore, along with thousands of other items immediately needed, but also rolling stock for the mine transportation system.

Southward along the route to the Cerro Bolivar area, roadbed was rapidly prepared. The highway, which would generally parallel the rail line, had first priority for the moving of construction supplies. Truck convoys carried cargoes of all shapes and sizes. As part of the program for the ore-gathering system, the contractors had to erect 13 major bridges across tributaries of the Caroni. They also had a couple of underpasses to put in, and several thousand drainage structures.

As operations extended ever farther along the route, outposts called fly camps were set up at intervals for the accommodation of equipment operators, surveyors, and their helpers. House trailers were favored for their versatility as well as mobility. They were adapted as mess halls as well as sleeping quarters and, thanks to modern refrigeration and kitchen facilities, the food served was always varied and wholesome. As for sleeping quarters, while the North Americans stuck to their familiar beds, Venezuelan workmen preferred the *chinchorros*, or hammocks.

Parties of surveyors pressed on through savanna and jungle, with a special group wielding machetes to clear away undergrowth for a view of the line ahead. They toiled up the slopes of Cerro Bolivar, surveying right of way for the tracks that would be winding to the crest. Construction crews gained a foothold around the top of the hill. Day after day, fresh sets of holes were drilled. Day after day, the

Palm-thatched huts on stilts at Indian village in the Orinoco delta. This type of construction in another area of the country inspired early explorers to use the name Venezuela, meaning Little Venice.

powder men placed their charges of dynamite. Bulldozers swept the loosened material down the slopes, and the track grade took shape. Before the end of 1952 all remaining gaps in the supply line were filled in. The ribbon of right of way winding around the hill was now connected with the new highway which ran northeastward 90 miles to the Orinoco.

In February, 1953, Benjamin F. Fairless, chairman of the Board of U. S. Steel, paying his first visit to Venezuela, keynoted the spirit in which the Orinoco Project was being conducted when he spoke at a luncheon given in his honor by Caracas businessmen.

"Our respective interests," he said, "are mutual. We are partners in this venture. The purpose of our partnership is to transform iron into gold – not through the mysterious black magic of the ancient alchemists, but through the modern miracle of mutual incentive under a system of free enterprise."

Several days later he inspected Cerro Bolivar. He was accompanied by a group that included M. W. Reed, Executive Vice-president of U. S. Steel, and E. M. Voorhees, chairman of the Finance Committee. It was a happy occasion for Mack Lake when he led these men into an exploratory tunnel to see for themselves what lay beneath the surface of the hill.*

Through the months that followed, drillers patterned the hillside with holes into which charges of dynamite were loaded. Power shovels with six-yard buckets cleaned out the blasted ore to make new access benches.

Current would be needed for a new electric shovel, for maintenance shops and other installations on the hill. And to carry that current, poles were marching up the slopes. In the valley, near the base of the hill, a large new building contained two Diesel generators which would supply power to Cerro Bolivar and also to the nearby townsite of Ciudad Piar. Here was a miniature modern city whose creation was part of the Orinoco Project, with row after row of houses.

The Orinoco River – one of the world's great waterways – was to be conditioned for direct north-

* This was Mack Lake's last inspection of Cerro Bolivar. He died in San Francisco less than two years later.

ward shipment of iron ore. This necessitated the dredging of a total of 32 miles of the 172-mile course from Puerto Ordaz to the Serpent's Mouth at the Gulf of Paria. While shorter than the Mississippi, the Orinoco brings down about the same volume of water, reaching flood peak in August, heavily charged with sediment. A long-range program of channel improvement was started in March, 1952.

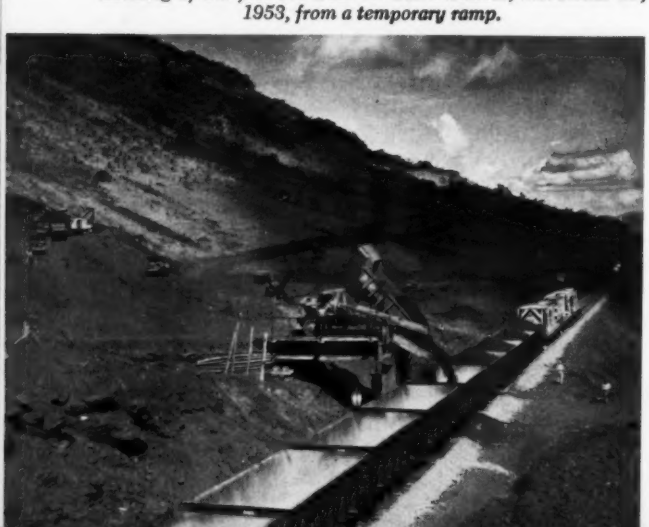
Hydraulic dredges dropped their cutter heads to the river bottom and sucked up sand and silt and pumped it to shore through large-diameter pipe lines floating on pontoons. Altogether, some 33,000,000 cubic yards were disposed of in 19 months of operation, opening up an ocean-going ship channel 250 to 400 feet wide at low water. Pile dikes were placed at critical points to keep the channel from filling in.

Hydrographic survey parties carried out a program of soundings and triangulation. Running back and forth across the river, a team on a motorboat used a fathometer in co-ordination with instrument men on shore, thus charting the channel. Toward the end of 1953 aids to navigation were installed all the way from Puerto Ordaz to the sea. There were 30 beacons at intervals along the shore and 57 in the stream itself, plus 30 floating buoys.

It was a red-letter day when the freighter *Paul Honold* arrived at Puerto Ordaz in November, 1953, although many ships had preceded her since the caisson dock was completed in 1952. What gave special significance to the coming of the *Paul Honold* was that she was an ore-carrier, the first to be berthed here, and would soon take her place with others in the transporting of Cerro Bolivar iron ore. An added significance was that she was now delivering the first consignment of ore cars for the Cerro Bolivar ore-haulage system. There were 62 of them to be off-loaded, of 90 gross tons carrying capacity each. More would be brought later until there were 560. The ore cars heralded the beginning of production, less than two years after the first freight load.

Astonishing changes had taken place along the Puerto Ordaz water front by the fall of 1953. In the course of just a few months, a combination of complex steel structures had risen against the sky. These were the ore-handling facilities, which were now almost ready for operation.

Loading of the first ore train on Cerro Bolivar, November 27, 1953, from a temporary ramp.



To furnish electricity for the ore-handling machinery and all other industrial and domestic needs of the new community of Puerto Ordaz, a powerhouse had been erected on the nearby bank of the Caroni River.

Another vital installation was the permanent water system, which went on stream in mid-November. Water was pumped from the Orinoco River to a modern plant. The volume treated was 1,000,000 gallons per day, which, with a few modifications, could be stepped up to 2,000,000.

Puerto Ordaz had lost much of the rawness of a construction camp. Many of the permanent houses were already built, furnished, and occupied. Eventually Puerto Ordaz, like Ciudad Piar at the mine, would become a full-fledged little city, with recreation buildings, bachelor and family quarters, church, school, hospital, cafeteria, commissary, and laundry. Indeed, the laundry was already in business. It was a wonderful asset in a climate where clothing quickly wilts and soils. Still carrying on in temporary quarters was the Puerto Ordaz school, but its staff and the number of its pupils had grown with the coming of more and more resident families.

In the Puerto Ordaz yards, complete and up-to-date shops were being built. Here all major mining and operating equipment, including rolling stock, would be kept in condition.

All this time, the rail ore-gathering system between Puerto Ordaz and Cerro Bolivar was nearing completion. Of great importance to it was a rock quarry a few miles south of the Orinoco. Blasted granite was dumped into a primary crusher from which it was conveyed to a secondary crusher. The plant produced aggregate for concrete, and ballast for grades on the haulage system. From a pit beneath a stockpile of ballast a belt brought up carload after carload through a tunnel to a loading ramp.

The roadbed was finished, but ballast cars continued their work, hauling crushed rock for the final grading of the track. Altogether, some 425,000 cubic yards of rock of all sizes had been produced and sent out from the quarry. After the spreading of the last ballast, the shoulder of the roadbed was evened off by a special plow. Just behind, a pair of power jacks lifted the track to its final position. An electric multi-tamper followed the power jacks, its steel fingers probing into the ballast and compacting it. The rails were moved into precise alignment under the guidance of an instrument man. The track was standard gauge and the rail came in 39-foot lengths, weighing 132 pounds per yard for the main track. The rail system was now virtually finished except for sidings on the hill itself. Where the roadbed wound to the crest of Cerro Bolivar, it was found economical to use local iron ore as ballast rather than ordinary rock.

Among the visitors who observed progress at Cerro Bolivar was Clifford F. Hood, U. S. Steel's President, who arrived with a party of executives in mid-November, 1953. Guiding Mr. Hood's party was Francis Thomas, new President of the Orinoco Mining Company. Stephen D. Bechtel, chairman of the board of Constructora Bechtel, managing construction for Orinoco, inspected the project on a number of occasions,

(*Continued on page 362*)

Food of Our Colonial Forefathers

Although Ill-Fed, by Modern Standards,
Colonial Settlers Had the Initiative and Energy
To Carve a Great Country from out of the Wilderness

By HARRY W. VON LOESECKE

On November 15, 1620, the *Mayflower* arrived at Cape Cod, and Captain Miles Standish with 16 well-armed men went ashore to find a suitable place for their companions to land. What they saw was a dreary countryside —

Washed with a cold gray mist, the vapory breath of the east-wind,
Forest and meadow and hill, and the steel-blue rim of the ocean
Lying silent and sad, in the afternoon shadows and sunshine.[1]*

Yet in this dismal wilderness which seemed to offer them nothing, they turned forward with confidence, and when the next autumn approached they could look back with some measure of satisfaction:

Seven dwelling houses and four public buildings on the main street were the outcome of their patient toil. Of the latter, one served for worship and for town meetings, the others for storehouses for provisions, clothing, trading stock and general supplies. They were at peace with the Indians round about; with some of them, indeed, on terms of intimate friendship. They resolved, therefore, with public proclamation to keep what may be called their Feast of Tabernacles. Besides the abundance of waterfowl, wild turkeys and venison, they had about one peck of corn meal per week to a person, which caused many to write their friends in England of their good cheer.[2]

Nevertheless, for three years the Plymouth Colony was on the verge of starvation, and maintained life only by strict rationing of its grain, by purchases from the Indians, and by making extensive use of fish, game, and wild food plants.

Despite the scattered settlements of fishermen and that of the Pilgrims at Plymouth, historians believe that the real founding of New England and the New World may be dated from 1630 when 2,000 well-equipped settlers arrived on the shores of what is now Boston Harbor. By 1640, the population of the New England colonies had risen to about 18,000.[3]

William Wood, writing of life in the early colonies around 1635, says:

Surely that place is not miserably poore to them that are there, where foure Egges may be had for a Penny and a quart of new Milke at the same rate: where Butter is six pence a pound and Cheshire Cheese at five pence . . . can they be very poore, where for foure thousand soules,† there are fifteen hundred head of cattle, besides foure thousand Goates, and swine innumerable.[4]

Corn (gunney wheat, Turkey wheat) was the most unfailing and valuable food supply of the early settlers, who found it "more precious than silver" and even used it as a medium of exchange. Every cleared patch of land contained corn, and

Round about the Indian village
Spread the meadows and the cornfields.[5]

Taught by the Indians, the colonists planted corn in hills, the same number of stalks to each hill, and used fish as fertilizer. Yields amounted to around 20 to 25 bushels per acre, which is about 10 bushels per acre less than the modern farmer gets, assuming that a bushel in colonial times was the same as it is today. When the hills of corn were heavily enriched with fish, yields as high as 40 to 50 bushels per acre were obtained. Pumpkin vines would be found running among the hills, and beans climbing the cornstalks.

John Josselyn, an English traveler to New England in 1638 and again in 1663, describes the corn of that time and some of its uses in food dishes:

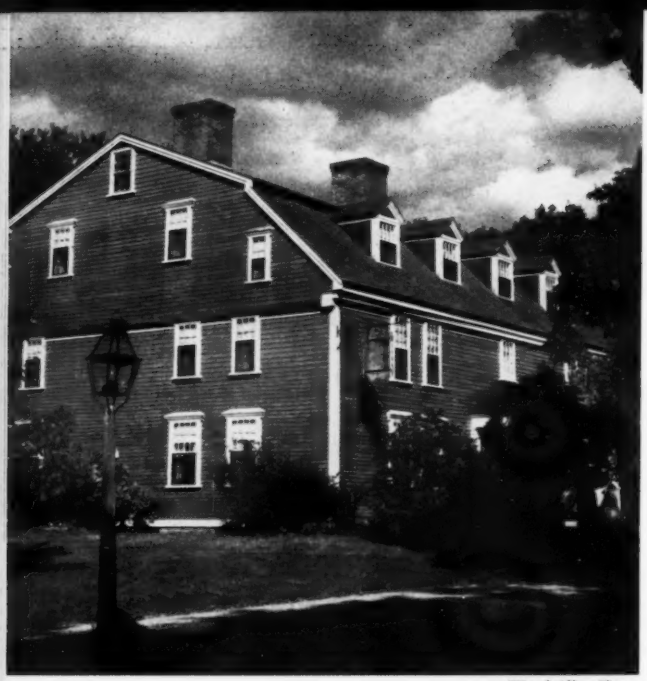
Indian wheat, of which there are three sorts, yellow, red and blew; the blew is commonly Ripe before the other a Month . . . The decoction of the blew corn is good to wash sore Mouths with: It is light of digestion, and the English make a kind of Loblolly [a thick gruel] of it to eat with Milk, which they call Sampe;‡ they beat it in a Morter and sift the flower out of it; the remainder they call *Homminey*, which they put in a Pot of two or three Gallons, with Water, and boyl it upon a gentle Fire till it be like a Hasty Pudden; they put this into Milk, and so eat it. Their Bread also they make of the Homminey so boiled, and mix their Flower with it, cast it into a deep Bason in which they form the Loaf, and then turn it out upon the Peel, and presently put it into the oven before it spreads abroad; the Flower makes excellent Puddens.[6]

At first corn was ground at home by pounding in a mortar. Hominy was sometimes made by boiling the corn kernels with leachings of wood ashes, these leachings being boiled down to the point where they could support an egg.

† This figure does not check with that given by Adams (cf. reference 3).

‡ This is apparently the name given by the Algonquin family of Indians. The Narraganset tribe of the Algonquins called it *nasaump*. Other names were *asapan, supaion, sepawn, sepon, suppawn*, depending upon the tribe.

* Please see numbered references, pages 360, 362.



Ward Allan Howe

Immortalized by Longfellow's Tales of a Wayside Inn *is this reminder of colonial days, at Sudbury, Mass.*

Later, hand mills, called querns (which consisted of two circular stones, one above the other) were utilized. The upper stone was turned by hand. Further improvements made use of windmills erected on the hills around Boston to catch the breeze. The huge vanes of these clumsy mills, creaking in the wind, were the source of awe and wonder to the Indians, who attributed their workings to some mysterious power held only by the white man.

Mills run by water and tide power were in use beginning about 1633 when a water mill was erected in Roxbury, and in 1634 another was built at Stoughton. It was not long before mills were scattered about the vicinity of Boston at Watertown, Dedham, Wayland, Sudbury, Reading, and Charlestown. Since these corn-grinding mills were situated on the banks of running water and on marshlands, they were difficult, and often dangerous to reach. One trip to such a mill, that ended in tragedy, is described by John Winthrop in his diary under date of 1646:

> A woman of Charlestown having two daughters aged under 14 years, sent them to the tide mill nearby with a little corn. They delivered their corn to the mill and returning back (they dwelt towards Cambridge) they were not seen till three months after, supposed to be carried away by the tide which was then above the marsh.[7]

Besides using corn as *sampe*, it was mixed with rye flour to make "rye and Injun bread"; *Sukquttahhash* (also called *misickquatash*), "corn seethed like beans," was another favored dish. From this we got our modern succotash, which today in commercial food processing means a mixture of corn and lima beans. In colonial times, however, succotash was made from corn and horticultural beans, and even today in New England succotash is considered a mixture of fresh corn and horticultural beans, salt pork, milk or cream, and butter.

John Winthrop (the Younger), who became Governor of Connecticut in 1635, and was a member of the Royal Society of England, carried out considerable experimental work with corn. He used corn for brewing beer, and called attention to the possibilities of making sugar and sirup from cornstalks, a thought that was revived even as late as 1852 in this country. Winthrop reported his results in "Description, Culture and Use of Maize," published in 1678.[8]

The art of preparing "roasting ears" was obtained from the Indians. They would "lap their corn in rowles within the leaves of the corn and so boil it for a dainty."

Wheat was another cereal crop of the early colonies. The crop began to fail in eastern Massachusetts before 1700, and by the end of the Eighteenth Century had practically disappeared from the state. Black stem rust and the Hessian fly took their toll. The cereal, however, grew well in the middle colonies where yields of from 10 to 15 bushels per acre were obtained. The failure of the wheat crop in eastern Massachusetts made it necessary for Boston to import grain from Connecticut and western Massachusetts, but such supplies soon became unreliable, and by 1750 breadstuffs were being regularly imported from New York, Philadelphia, and Baltimore. By 1790, flour was even being imported into the former exporting regions of the Connecticut Valley.

Grain Threshing

In the late Seventeenth Century, grain in New England was usually threshed with a flail, but in the middle colonies during the Eighteenth Century the general practice was to tread out the grain with horses. Two men and six horses could thresh about 100 bushels a day. Winnowing was performed by throwing the grain against the wind, and by running it through sieves. In 1780, horsepower threshing was experimented with, but practical application did not result until considerably later. About this same time, one miller in Philadelphia mechanically conveyed his grain from one part of the mill to another while it was being cleaned, ground, bolted, and packed. Capacity of his mill was said to be 100,000 bushels a year.[9]

There were apparently no professional bakers in the early Plymouth Colony, and the first baker in the New World seems to have been a William Hudson, who settled in Boston around 1640.[10] In the same year an act was passed making it unlawful to make bread "finer than to afford at twelve ounces the two-penny loaf," and in 1646 the first general law governing the price of bread and regulating the acts of the baker was passed. So, price control in the United States is nothing new. A more explicit act was passed in 1720; it was repealed in 1797.

Some pretense was even made to establish standards of identity, for in 1763 a Boston law required that brown bread not exceed one-half Indian meal. Just how such a law could be enforced, with the limited knowledge of food technology of that day, is difficult for us now to understand. There was no uniformity in the composition of bread, nor in its price, throughout the colonies. Thus, Benjamin

Franklin in his autobiography makes this apparent by a Philadelphia experience:

> Then I walked up the street, gazing about till near the market-house I met a boy with bread. I had made many a meal on bread, and, inquiring where he got it, I went immediately to the baker's he directed me to, in Second-street, and ask'd for bisket, intending such as we had in Boston; but they, it seems, were not made in Philadelphia. Then I asked for a three-penny loaf, and was told they had none such. So not considering or knowing the difference of money, and the greater cheapness nor the names of his bread, I had him give me three-penny worth of any sort. He gave me, accordingly, three great puffy rolls. I was surpriz'd at the quantity, but took it, and, having no room in my pockets, walk'd off with a roll under each arm, and eating the other.

Fairs and markets were established in Philadelphia in the early years of the settlement. These institutions were designed to bring the producer and consumer together under conditions of free competition and to prevent abusive practices of the middleman. In 1693 market regulations were set up which were not always popular with the producer. A weekly market was established in Hartford in 1643 and annual fairs held there and in New Haven and Providence. A 1709 writer making an observation of the Boston market says: "The Town of Boston is plentifully supply'd with good and wholesome Provisions of all sorts, not inferior to those in England."

Rye and barley were also raised in the colonies, the former being quite often mixed with corn and wheat to make "rye n' Injun" bread. The rice plantations of the southern colonies, however, were the El Dorados of the southern settlers. Huge fortunes, reflected in the splendor of the magnificent homes and genteel living of the plantation owners, were derived from rice growing. The Virginia colonists experimented with rice growing in 1647, but this never resulted in the establishment of a rice culture of any consequence. Rice was cultivated in South Carolina near Charleston prior to 1685, later its cultivation expanded into southeastern South Carolina and then northward to the northeastern part of the state and along the lower Cape Fear River in North Carolina. Georgia was another rice-growing colony, and rice production expanded rapidly in all the southern colonies until 1775, when annual exports approached some 66,000,000 pounds.

Rice Growing

Most rice growers of the colonial period cut their rice with a sickle. The harvested rice was bound in bundles, carried to the barnyard, and stacked until the threshing season. Threshing was done with a flail. The husks were removed from the grain with mortar and pestle, and the chaff was blown off with hand fans. Water mills came into use in 1787, and tide mills around 1791. It was not until 1832 that millstones were used.

The colonials had plenty of vegetables in the summer. Cabbage, lettuce, carrots, parsnips, beets, pumpkins, squash, radishes, turnips, purslane, "pease (of all sorts, and the best in the World)," and beans.

Arthur Griffin

"They resolved, therefore, with public proclamation to keep what may be called their Feast of Tabernacles."

Sweet potatoes were extensively grown in the southern colonies, for the colonists there preferred them to corn. Such vegetables as turnips, pumpkins, squash, and parsnips were stored or dried for winter use. Excess turnips and parsnips were fed to livestock.

Shredded cabbage dressed in vinegar was evolved by the Dutch settlers of Manhattan. We know this dish today as coleslaw. Baked beans as a New England dish, which survives to this day, was born in colonial times as an expedient to eliminate cooking on Sunday, a day given over to rest and prayer. The beans were baked with salt pork and molasses all Saturday, so as to be ready to be served on the Sabbath.

It was not until the beginning of the Eighteenth Century that potatoes started to find favor in the New World. Benjamin Franklin mentions them in his autobiography of his early youth, when in 1722 he had a fling at being a vegetarian: "I made myself acquainted with Tyron's manner of preparing dishes, such as boiling potatoes or rice, making hasty pudding, and a few others . . ." Tyron was apparently a food faddist of the time who recommended a vegetable diet. Potatoes must have been well known in England during the Seventeenth Century, for the dupe Falstaff, in Shakespeare's *Merry Wives of Windsor*, shouts: ". . . Let the sky rain potatoes . . ."[11]

Introduced into the Carolinas by the Scotch-Irish colonists in 1718, it was not until after the Revolution that potatoes came into general use as a food in New England, and later in New York and Pennsylvania.

The early settlers had a considerable variety of fruits during the season, but in winter their diet of fruit was limited chiefly to apples, either as such or as cider. In early summer wild strawberries were plentiful in New England, and in such abundance "that the Fields and Woods are died red." Josselyn,

in his travels in 1638 in New England, was impressed by the wild fruit:

> Bell Berries, they usually eat them put into a Bason, with milk, and sweetened a little more with sugar and spice, or for cold stomachs, in Sack. The Indians dry them in the Sun, and sell them to the English by the Bushell, who make use of them instead of Currence, putting them into Puddens, both boyled and baked, and into water gruel.[6]

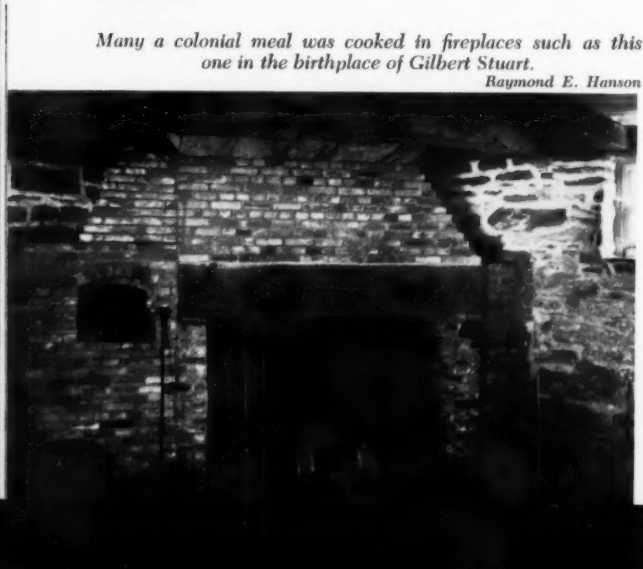
Also known to early settlers were the wild cherry [probably the chokecherry (*Prunus virginiana*) and the wild black cherry (*P. serotina*)] and the "Plumb Tree, several kinds, bearing some long, round, white, yellow, red and black. Plums; all differing in their fruit from those in England."[6]

Cherries and plums were sometimes preserved for winter use by packing in large stone jugs, well filled and made "proof against air and water." The filled jugs were sunk in the bottom of a cold spring.[12]

As early as 1639, apples were grown on Governor's Island in what is now Boston Harbor. In 1753, apples, pears, peaches, plums, quince, cherries, and crabapples were introduced into South Carolina and north Georgia. Apples were utilized in New England chiefly for making cider, the common drink of all its inhabitants. (This implies the fermented juice. There were no means of keeping the juice from fermenting.) The dark, cold cellar of most every house, whose dwellers were financially situated to own a house with a cellar, contained at least one barrel of cider. Pitchers of it were brought up at every meal and in the morning and evening. Even the children were allowed cider mixed with milk when the latter was scarce. As early as 1638 Josselyn reported: "Syder is very plentiful in the countrey ordinarily sold for ten shillings a hogshead."[6] The Puritans drank switchel, a mixture of molasses, vinegar, and ginger water; while the Swedish settlers of Delaware, New Jersey, and Pennsylvania preferred sillabub, which consisted of lukewarm milk, wine, and sugar. Apples were also sliced and dried, and cider brandy (applejack) was prepared by distilling the fermented juice. There was no Internal Revenue Service in those days.

Peaches were grown around New York and in New Jersey and Pennsylvania. The bitter New England winters prohibited extensive growing in that region. In Pennsylvania, peaches were sliced and dried for winter use.

Many a colonial meal was cooked in fireplaces such as this one in the birthplace of Gilbert Stuart.
Raymond E. Hanson



The colonists in the New World found many serious plant diseases, such as fire blight of pear and apple, and downy mildew of grapes. Little attention was given to cultivation, pruning, and control of insect pests. As a result, most of the orchards were in a continuous state of slow death. Entomology was practically an unknown science in the New World, as it was not until between 1734 and 1742 that the French naturalist René de Réaumur issued his *Memoires pour Servir à l'Histoire des Insectes*, in six volumes. These books were probably little known to the colonial fruit growers.

In 1750, William Prince began to develop a commercial fruit tree nursery at Flushing, Long Island. This venture grew to be the first extensive collection of fruits in the United States. At the close of the Revolution, George Morgan settled on a farm which is now a part of Princeton University, where, among other activities, he experimented with methods of insect extermination. The role of George Washington and Thomas Jefferson in scientific farming during the colonial period is too well known for further discussion.

Besides wild game that abounded in the forests, the diet of the early colonists was supplemented by beef, pork, lamb, and mutton. The raising of beef cattle and livestock for sale began very early, and in 1655 salted meat was being shipped from the colonies to the West Indies. Farmers in the rural districts drove their cattle to slaughter houses in Brighton, Mass., New York, and Philadelphia. There is still a slaughter house at the same site in Brighton, but of course it is now modernized.

Use of Cattle

Cattle were allowed to roam at will for feeding and there was little provision for their shelter or food during the winter. Consequently, cattle raising in the northern New England colonies was not successful, but in southern New England (around Narragansett Bay where the climate was milder), the venture was quite successful. The mild climate of the southern colonies encouraged cattle raising, and cattle became so plentiful there they were hunted, at times, like deer.

Swine were fed kitchen garbage and allowed to forage in the woods for nuts. In most of New England, hogs were slaughtered at 18 months when they weighed about 200 pounds, but in eastern Massachusetts they were generally slaughtered when they weighed between 250 and 400 pounds. As early as 1660 a profitable pork packing trade for the West Indies developed in the Connecticut Valley.

Sheep were numerous in New England, and in 1645 the Bay Colony towns of Massachusetts were encouraged to raise sheep, chiefly for their wool, for lamb was not a very popular meat. The typical sheep of those days may have stood two and a half feet high and dressed out at from 10 to 15 pounds per quarter, or exceptionally, at 20 pounds.[13]

In 1789, land was cheap and meat abundant in the American colonies. Corn was fed to cattle and hogs so that the colonists could enjoy the meat. But in

(*Continued on page 352*)

THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

National Economy and Physics Teaching

WHEN 112 members and guests attended the 309th meeting of the Alumni Council on the evening of March 28 they had opportunity of hearing Eli Shapiro, Professor of Finance and Associate Dean of the School of Industrial Management, speak on the nation's economy; they also heard Nathaniel H. Frank, '23, Head of the Department of Physics at M.I.T., speak on instruction in physics. Hugh S. Ferguson, '23, opened the Council meeting as president of the Alumni Association by calling for reports on Council business.

As Secretary of the Alumni Association, D. P. Severance, '38, announced changes in class affiliation for two Alumni, and stated that for the month ending March 28, eight members of the Council had visited 10 alumni clubs in Tokyo, Monterrey, and Mexico City, as well as in seven cities in the United States.

Dwight C. Arnold, '27, has accepted chairmanship of a committee to plan a conference at the Institute of such working personnel of the Association as club officers, class officers, honorary secretaries, and members of the Educational Council. Such a conference, which will probably be held in mid-September, would provide opportunity for these Alumni to discuss common problems on the campus where they may come into close contact with present day facilities which the Institute has to offer. Such a conference for the Institute's unofficial ambassadors of good will would help to publicize facilities that have been developed in the postwar era and which may not be well known to those who have not visited Cambridge in recent years. John J. Wilson, '29, will be deputy chairman, and other members of Mr. Arnold's Committee are: Theodore T. Miller, '22, John E. Burchard, '23, Henry B. Kane, '24, Bruce F. Kingsbury, 2–44, George R. Harrison, and H. E. Lobdell, '17, ex-officio, Hugh S. Ferguson, '23, ex-officio, D. P. Severance, '38, ex-officio.

John A. Lunn, '17, a member of the Alumni Fund Board, reported that, as of the March 28 Council meeting, 9,200 Alumni had contributed a total of $342,000 toward the laboratory in physical sciences to be built as a memorial to Karl T. Compton. These figures represent 400 more contributors than last year at the same time, and the amount exceeds last year's final figure by $108,000.

President Ferguson then called on Dr. Shapiro who discussed the nation's economy and business climate. He told of the role each can play, their relative effectiveness, ease of operation, and illustrated how each had been used in the past and showed that there is no necessary conflict between physical policy and monetary policy.

As final speaker for the evening, Dr. Frank told the Council of the state of undergraduate physics instruction at M.I.T. In particular, he told of the changing emphasis in first and second year physics laboratory from the multiplicity of routine experiments formerly required to the present requirement for few laboratory experiments but each designed to emphasize modern physics without requiring the student to have a greater knowledge of that subject. The undergraduate physics instruction does not attempt to cover a specified storehouse of factual data. On the contrary, the fundamental core of the course is now determined by the individual classroom instructors and the individual laboratory instructors, with a tendency to take physics back to the area of an experimental science and away from the category of a blackboard subject.

Even though there are 1,900 freshmen and sophomores all taking physics, and an additional 300 undergraduate physics students and 200 graduate physics students, this teaching is shared by senior members of the faculty and by experienced research men. For example, of the 66 sections in the first two years of physics, only seven sections are handled by graduate student assistants. All other sections are taught by members of the faculty and other post-doctoral staff members.

Following a question period, the members of the Council had the opportunity to preview the film "New Horizons" illustrating industrial applications of electronic and nuclear science as well as important activities of the Institute in these fields.

Wright Lecture

C. STARK DRAPER, '26, Head of the Department of Aeronautical Engineering at the Institute, will deliver the 43rd distinguished Wilbur Wright Memorial Lecture in London, England, on Thursday, May 19. The Royal Aeronautical Society of England has announced plans for the lecture and for a reception to follow it. Dr. Draper will speak on "Flight Control," discussing the subject from its beginnings in historical aircraft to the high-performance systems of today. Trends in both theory and practice will be described as parallel streams of development.

During the past 15 years Dr. Draper's research at M.I.T. has won him national and international recognition. Many developments in antiaircraft fire control and air-borne fire control equipment made under his supervision in the M.I.T. Instrumentation Laboratory are today in wide use by both the U.S. Air Force and the U.S. Navy. Dr. Draper has written extensively in the fields of instrumentation and control, has served as consulting engineer to many aeronautical and instrument companies and holds a number of patents for measuring and control equipment.

Before 1922, when he came to the Institute as an undergraduate, Dr. Draper studied in the schools of

Windsor, Mo., where he was born in 1901, and at the University of Missouri and Stanford University. He has been at M.I.T. continuously since 1922 becoming professor of aeronautical engineering in 1939 and head of the Department in 1951.

In 1946 Dr. Draper received the Medal for Merit and the Naval Ordnance Development Award for his wartime work in antiaircraft fire control. He holds the Sylvanus Albert Reed Award of the Institute of the Aeronautical Sciences, the New England Award of the Engineering Societies of New England, and a Testimonial of Appreciation from the Industrial Instruments and Regulators Division of the American Society of Mechanical Engineers. The Exceptional Civilian Service Award from the Department of the Air Force was made to Professor Draper by the Department of the Air Force in 1951, in recognition of distinguished service during the period 1947–1950.

Conserving Our Resources

How to plan for wise and efficient use of America's bountiful human and natural resources, to help end wasted riches and underemployed abilities, will be the subject of intensive research at the Institute during the next five years. Pietro Belluschi, Dean of M.I.T.'s School of Architecture and Planning, announced that a grant of $93,750 from Resources for the Future, Inc., will underwrite a five-year study at M.I.T. of the principles and methods of analyzing resource problems. The project will be in M.I.T.'s Section of Urban and Regional Studies in the Department of City and Regional Planning. It will be under the direction of Walter Isard, Associate Professor of Regional Economics. The results of this study – new ways to plan industrial expansion and human activities in terms of the resources available – should be useful, Dean Belluschi said, to numerous industries as well as to the local, state, and national government agencies.

In speaking of the new project, Dr. Isard pointed out that "America's continuance as a dominant economy of the world is contingent upon attaining a wise and efficient use of both God-given and man-made resources. The history of our country is replete with mistakes. With tremendous advances in technology and in forms of social organization, society has become increasingly complex. What principles and methods can we now use," asked Dr. Isard, "to plan intelligently and comprehensively to make the resources we have serve us most effectively?" These, said Dr. Isard, are typical of today's resource-planning questions: (1) How can we develop a program of water use over the next decades which will meet needs and be within our supplies? (2) How can we devise a transportation system – harbors, rivers, highways, airports, railroads – which will minimize congestion and permit low costs? (3) How can we achieve effective housing programs and urban rehabilitation and renewal?

"It is widely recognized among social scientists," continued Dr. Isard, "that our present methods of analysis are inadequate to cope with problems of this order . . . and our problems are steadily mounting in complexity." As an example, a comprehensive policy for future development of water resources in a region, Dr. Isard said, might require as a basis: (1) Estimates of future production, income, population, expenditures, and capital movements for the region involved. (2) Estimates of the future distribution of urban and rural population of the region, and of the geographic spread of industry within the region. (3) Estimates of the local demand for the product of each water-consuming industry. (4) Estimates of the needs by industries and population outside the region for the products of the region's industries. (5) Estimates of future water supplies, from all sources, for the region as a whole, and also for each local area which might be a potential water shortage area.

"Present methods of analysis," Dr. Isard said, "are inadequate to make such estimates as these. They involve processes so complicated that we have been able to study them only partially. Our research at M.I.T. will seek the methods by which problems such as these may be comprehensively attacked. New principles and methods must be developed if industries and governments are to achieve wiser resource policies." The study will involve the use of such new analytical tools as linear programming, industrial complex analysis, operations research, inter-regional input-output analysis, game theory, and gravity models. These are new analytical developments in economics and mathematics which are unfamiliar to most planning people. Their use is made possible by the development of such high-speed computers as M.I.T.'s Whirlwind I.

The subject of regional resource development is one of the major elements in the program of the Section of Urban and Regional Studies at M.I.T. Other studies under way include analysis of the "cityscape" – to develop principles and techniques to be used by architects and planners in designing a more satisfactory environment; regional analysis of industrial location; and the interrelationship of transportation and land development patterns of metropolitan regions. Resources for the Future, Inc., is a nonprofit, tax-exempt corporation, with headquarters in Washington, D.C. It was established in October, 1952, with the co-operation of The Ford Foundation. Its purpose is to improve the development, conservation, and use of natural resources through programs of research and education, in the social sciences.

Irvin S. Cohen: 1917-1955

The death of Irvin S. Cohen, for seven years an assistant professor of mathematics at M.I.T., occurred in New York on February 14, 1955. Professor Cohen, on leave of absence at Columbia University since last July, had published a number of papers in the fields of algebra and algebraic geometry and had frequently been an invited speaker at colloquia at other universities.

He was born in Baltimore, Md., and received the degrees of bachelor of arts (1936) and doctor of philosophy (1942) at Johns Hopkins University. Before joining the Institute staff, Professor Cohen had served as Pierce Instructor at Harvard University, and instructor and assistant professor at the University of Pennsylvania.

Litchfield Honored

As reported on these pages last month, Paul W. Litchfield, '96, chairman of the Board of the Goodyear Tire and Rubber Company, was honored at the banquet held in Cleveland on February 26 as part of the Third Midwest Regional Conference.

He is shown, at the right, receiving the certificate from Hugh S. Ferguson, '23, President of the Alumni Association which "honors Paul Weeks Litchfield, '96, who, in his Industrial Voyage, has exemplified to the fullest degree the creative and humanitarian roles of the engineer."

Mr. Litchfield also received a set of commemorative Wedgwood plates showing scenes at M.I.T.

Rehman Photo Service

Among those attending the banquet at the Third Midwest Regional Conference in Cleveland on February 26 were: Manson Benedict, '32, Professor of Nuclear Energy, Paul W. Litchfield, '96, honored guest, John E. Burchard, '23, Dean of Humanities, and William H. Robinson, Jr., '24, toastmaster. Speakers at the banquet included Richard S. Morse, '33, and Dean Burchard.

Commencement Speaker

Sir Roger Makins, British Ambassador to the United States, will be the principal speaker at commencement exercises at the Institute on June 10. Sir Roger, who was appointed Ambassador to the United States in 1952, has been in the British foreign service since 1928. He holds the rank of Knight Grand Cross of the Order of St. Michael and St. George and is a Knight Commander of the Most Honorable Order of the Bath. Lady Makins is the former Alice Davis, daughter of the Honorable Dwight F. Davis, Secretary of War in the Coolidge administration, later Governor-General of the Philippines, and the donor of the Davis Cup (tennis).

Sir Roger was educated at Winchester and at Christ Church, Oxford, graduating with First Class honors in history in 1925. In the same year he was elected a fellow of All Souls College, Oxford, and two years later was admitted to the Bar. In 1928 he forsook the law for the foreign service. His first overseas assignment was in Washington, where he served as third, and later as second, secretary from 1931 to 1934. From 1934 to 1942 Sir Roger was in the Foreign Office in London, acting as adviser on League of Nations Affairs, as secretary to the British delegation at the Evian Conference and to the Inter-Governmental Committee on Refugees, and in 1941 making a trip to New York for the International Labor Organization Conference.

In 1942 he was promoted to counsellor and assigned to the staff of the Resident Minister in West Africa. From 1943 to 1944 he was assistant to the Resident Minister at Allied Headquarters Mediterranean Command, first at Algiers and later at Caserta. During this tour of duty he worked in close association with the staff of the Supreme Commander, General Eisenhower, and his successor, Field Marshal Wilson. At the end of the war Sir Roger was named economic minister in Washington, and during the next two years he represented Great Britain at a number of conferences, including the Food and Agriculture Organization and the United Nations Relief and Rehabilitation Administration. Returning to the Foreign Office in 1947, he remained based in London for the next five years, first as assistant, then as deputy under-secretary of State. It was in this post that Sir Roger assumed responsibility for supervising the Economic Departments and later also the North American Department.

During this time, he undertook a number of overseas missions. He attended the Commonwealth Conference in Ceylon in 1950, at which the Colombo Plan was launched. Two years later he was sent by the Foreign Secretary on a special mission of inquiry to the Persian Gulf area. In this period he also paid three visits to the United States: in 1949 with Ernest Bevin and Sir Stafford Cripps; in 1950 with Clement Attlee; and in 1952 with Winston Churchill and Anthony Eden.

Student Conference

STUDENTS and deans from all sections of the country represented 80 colleges at the three-day intercollegiate conference on "Selectivity and Discrimination in American Universities" at the Institute on Friday, March 25. Frederick May Elliot, President of the American Unitarian Association, and James R. Killian, Jr., '26, President of M.I.T., delivered the opening speeches on Friday afternoon at the Kresge Auditorium. Everett C. Hughes, Chairman of the Department of Sociology at the University of Chicago and John Hope Franklin, Professor of History at Howard University, discussed the discrimination problems on Saturday morning.

The Saturday afternoon session was featured by a panel discussion on "Contemporary Attitudes and Viewpoints" with Ralph McGill, editor of the Atlanta, Ga., *Constitution*; Clarence Berger, Dean of Administration at Brandeis University; Jonathan W. Daniels, editor of the Raleigh, N. C., *News and Observer;* and Louis M. Lyons, curator of the Nieman Fellowship at Harvard University. On Sunday morning Carl R. Woodward, President of Rhode Island University, and Eugene S. Wilson, Dean of Freshmen at Amherst, presented their views on restrictive clauses in fraternal organizations. The final plenary session on Sunday afternoon was addressed by John Ely Burchard, '23, Dean of Humanities at M.I.T. The conference was planned by M.I.T. students to develop an understanding of the causes and the problems created by the existence of discriminatory practices in some American colleges. It brought into contact 200 students, administrators, and professors to discuss these questions in small discussion groups.

Creativity and Science

CHARLES A. THOMAS, '24, President of the Monsanto Chemical Company, delivered the 1955 Arthur Dehon Little Memorial Lecture at the Institute on Tuesday, April 12. Dr. Thomas spoke on "Creativity and Science" in the eighth in this series of distinguished lectures. Open to the public, the lecture was delivered in the Kresge Auditorium at M.I.T. at 8:30 P.M. Dr. Thomas has achieved distinction as a chemist, as an administrator, and as a statesman. Dr. Thomas was a pioneer in the development of tetraethyl lead, now used widely in motor fuels; since 1936, first as research director, later vice-president, and now president of Monsanto, he has been responsible for the Company's technical direction and research.

Born near Lexington, Ky., in 1900, Dr. Thomas attended Transylvania College before coming to M.I.T. in 1920; here he received the master of science degree in chemical engineering. His industrial career began with service as a research chemist at the General Motors Research Corporation and later with the Ethyl Gasoline Corporation. Dr. Thomas, together with an associate, organized in 1926 the Thomas and Hochwalt Laboratories; these were acquired 10 years later by the Monsanto Chemical Company, of which Dr. Thomas then became central research director.

During World War II, Dr. Thomas was one of the principal scientists in the development of the atomic bomb, having charge of the final purification and metallurgy of plutonium, the 94th element. He became project director of the Clinton Laboratories at Oak Ridge, Tenn., when the Monsanto Chemical Company contracted to operate this project. In recognition of his wartime work on atomic energy, Dr. Thomas was one of a group of scientists who received the Medal for Merit in 1946; the citation, in part, said that "his initiative and resourcefulness and his unselfish and unswerving devotion to duty have contributed vitally to the success of the atomic bomb project."

Dr. Thomas' work as one of five coauthors of the so-called Acheson-Lilienthal report on the international control of atomic energy typifies a role of outstanding public service. He has been chairman of the Scientific Manpower Advisory Committee of the National Security Resources Board and is now one of seven consultants on President Eisenhower's National Security Council. Dr. Thomas holds the Industrial Research Institute Medal for outstanding achievement in the administration of industrial research and the American Institute of Chemists' Gold Medal for work in research administration. He has been president and chairman of the Board of Directors of the American Chemical Society and in 1953 was presented the Perkin Medal, the highest award for achievement in American industrial chemistry.

The Arthur Dehon Little Memorial Lectureship was established at M.I.T. in 1946 in memory of the founder of Arthur D. Little, Inc. Dr. Little was most widely known as an outstanding pioneer in the application of science to industry. He was a leader in such fields as chrome tanning, artificial silk, water-proof papers, wood-waste utilization, and other industrial chemical operations.

The purpose of the Arthur Dehon Little Lectures is to promote interest in and stimulate discussion of the social implications inherent in the development of science. Previous lecturers have included: J. Robert Oppenheimer, Director of the Institute for Advanced Study, Princeton, N.J.; Robert E. Wilson, '16, chairman of the Board of Standard Oil Company (Indiana); Detlev W. Bronk, President of the National Academy of Sciences; and Leonard Carmichael, Secretary of the Smithsonian Institution.

Newell C. Page: 1880-1955

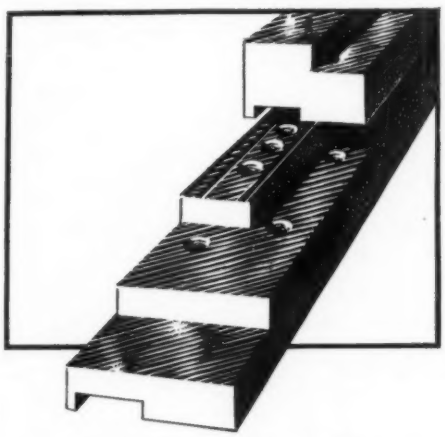
NEWELL C. PAGE, '02, Professor of Electricity, Emeritus, who served on the M.I.T. staff for 43 years before retiring in 1945, died in Winchester on February 15, 1955. He was 74 years old. Professor Page was born in Newburyport, Mass., and received the degree of bachelor of science at M.I.T. He joined the Institute staff in 1902 as an assistant in the Physics Department, was promoted to instructor two years later, and in 1912 was named assistant professor. Professor Page was appointed associate professor of electricity in 1919, and full professor in 1926.

One of an old school of fine teachers, he devoted his professional life to teaching and to helping his students.

BUSINESS IN MOTION

To our Colleagues in American Business . . .

These sketches show a Revere Extruded Shape in Copper, and the electrical part made from it. The part, called a "fishtail", is a terminal block on a high-frequency transformer, used in induction heating apparatus. Such equipment produces a high frequency field of sufficient power to heat or even melt metals placed within it. (It is often the case that the coil through which the oscillating currents flow is made of Revere Copper Tube.) Applications of this method of heating are numerous. For example, vacuum tubes are heated by induction to drive air and gases from the metal parts while the vacuum is being established. It is sometimes necessary to cast metal in a vacuum; induction heating makes this possible. The speed, economy and uniformity of the method also make it highly attractive for such tasks as heat-treating and hardening, brazing, soldering, and heating prior to forging, upsetting, or other hot working. This is a fast-growing modern method, and the manufacture of the equipment for it is an industry in itself.



Because it is a part of the electrical industry, it uses a lot of copper. And it has found that Copper Extruded Shapes by Revere contribute to both speed and economy. The fishtail illustrated formerly was machined from solid copper bar. On a typical run, the total manufacturing cost for a certain number of pieces was $35,000. Because of the considerable amount of transverse milling required, you might think that an extruded shape would be of doubtful economy. However, analysis indicated that appreciable savings were possible, even though the bar cost 10 cents less per pound. Eventually, these figures came out: using the extruded shape, total cost on the same number of fishtails was $25,700. That meant a saving of $9,300, or 26.6%.

Extruded shapes sometimes can indeed work miracles. The shape shown is relatively simple. However, quite complex shapes are possible, some so complex that they could not be produced by any other method, giving consideration to weight, strength, and cost. Another advantage of the shape is reduction of scrap. In some cases, a finished part is produced merely by cutting pieces off a shape, when scrap almost disappears. The limitation on the extrusion process is this: all design details must be parallel to the axis of extrusion. But don't let that scare you. The fishtail was finished by a number of operations at angles to the axis, and the shape still saved a lot of money.

Revere would be glad to go into details with you on the application of extruded shapes in copper and copper-base alloys, and aluminum alloys. Perhaps we can help you find ways to new economies. And if you use none of those metals, we suggest that you consult the people from whom you buy your materials. Take them into your confidence and add their knowledge to yours. It should pay you to do so.

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FOOD

(*Continued from page 346*)

Europe at that time, land was dear and meat a luxury, so Europeans ate bread and other cereals.

There were no means of keeping slaughtered meat fresh for long periods. Therefore, slaughtering was done in the fall when the first frost lay long in the meadows under the morning sun. If the weather turned warm, slaughtered meat was stored in spring houses or wells. Probably there was some natural ice cut locally for local use, but the ice trade in the United States did not start until 1805. The ice trade was initiated by Frederic Tudor of Boston,[14] who started cutting ice from a pond in Saugus – a small town adjacent to Lynn, north of Boston.

Meat in the stage of incipient spoilage was not necessarily thrown away. Robert May, for instance, describes a method of preserving tainted venison:

> Boil water, beer and wine vinegar together, and some bay leaves, time, savoury, rosemary and fennel, of each a handful, when it boils put in your venison, parboil it well and season it as aforesaid.[15]

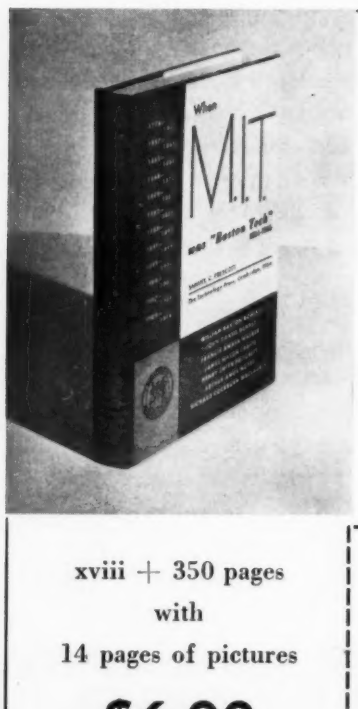
Pork was salted for better keeping; a little beef was also preserved by salting. Salt was needed, not only for preserving meat, but for preserving fish. The need for salt tied the frontier settlers to the Atlantic Coast. Many attempts were made to make salt from sea water, and as early as 1620, a saltworks was established at Cape Charles, Va., and in 1625 there was another at Cape Ann in Massachusetts. John Winthrop, Jr., was the leader in these projects, which were unsuccessful, and it was necessary to import salt into the colonies.

During the Revolution, salt was prepared along the Atlantic Seaboard by boiling sea water, and after the close of the war an extensive system of salt making grew up around New Bedford and Cape Cod. These works depended upon solar evaporation. However, at Harwich, Falmouth, and Barnstable on the Cape, salt was made by boiling sea water. It required about 250 gallons of sea water to obtain a bushel of salt. In 1797, extensive salt wells were being worked at Onondaga in New York, and in that year, 25,474 bushels were produced there.[16] Much of the salt made in this period was of poor quality and not well suited for salting pork and fish.

Fish, particularly the cod, brought succor to the early colonists. Codfish was so important to the colonists, that it was reverently designated as the "Sacred Cod." Today, a sample of the Sacred Cod hangs in the State House on Beacon Hill in Boston.

Gloucester, some 30 miles north of Boston, was founded in 1623 for conducting fishing operations. Even today this city on the New England coast is the haven of "they that go down to the sea in ships, that do business in great waters." In 1624, the fishing industry in the colony had so advanced that a ship laden with salt-cured fish was sent to England. Significant quantities of salted fish were soon being

(*Continued on page 354*)



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MORE INFORMATION ABOUT THE CORPORATE ALUMNUS PROGRAM:

A plan to match employees' gifts to their colleges, up to $1,000 in one year

Since the General Electric Educational and Charitable Fund announced the Corporate Alumnus Program on Nov. 23, 1954, many questions have been received about it. The answers to questions most often asked by G-E employees are reprinted below as a matter of general interest.

Q. Does the Program make any distinction between privately endowed and tax-supported colleges?

A. No. All colleges, which are otherwise eligible, are treated alike, irrespective of their source of support or type of control.

Q. May I also make contributions to any institution from which I earned an advanced degree?

A. Certainly, but the total of all your gifts will be matched only up to $1,000 in 1955.

Q. Supposing an employee completed part of the requirements for his degree at one college, and then transferred to another from which he received his degree — are they both eligible for "dollar-matching" gifts?

A. No – only the one from which he finally received his degree.

Q. Are there any restrictions on the use which the college can make of the contributions it receives from the Fund under this Program?

A. Practically, no. The payments will be made to the college to foster the over-all purposes of higher education—which admits of a pretty broad interpretation.

Q. To be eligible for the Program, do I have to have worked with General Electric for any specified period?

A. Yes, the rules require you to have had at least one year of continuous service in General Electric or one of its wholly-owned subsidiaries.

Q. What exactly is meant by "earned degree"?

A. You must have at least a bachelor's degree or equivalent. Associate or other short-program "degrees" and certificates do NOT count for eligibility. Nor, for that matter, do honorary degrees.

Q. Are men and women graduate employees equally eligible?

A. Yes.

Q. Is the Program limited to people in special job classifications?

A. Not at all.

Q. When contributing to my alma mater, to whom should I make out my check?

A. It will be helpful if you will make your check payable to the college or university itself, rather than to an alumni association, foundation, or other fund-raising agency. It is the responsibility of the chief financial officer of the institution to certify that the college actually received your contribution. When this is done, the requirements of the plan have been satisfied in this respect. However, making your check payable to the institution is a quicker and surer way of qualifying – but it is not obligatory.

Q. Now, about the eligibility of my college — what specifications is it required to meet?

A. Your college will qualify provided:

1. It is located within the U.S. or its possessions.
2. It is at least a four-year, degree-granting institution.
3. It is accredited by the appropriate regional or professional accrediting association.

HERE ARE THE RULES OF THE CORPORATE ALUMNUS PROGRAM

The Fund will match any contribution, made in 1955 before Dec. 15, by a General Electric employee to a college or university from which he earned a degree, under these conditions:

1. The employee's contribution, in order to qualify under this Program, must be the personal gift of the employee actually paid to the college or university during the calendar year 1955 and prior to December 15 of that year in cash or in securities having a quoted market value and not merely a pledge.

2. The college or university to qualify must be a four-year course, degree-granting institution, accredited by the appropriate regional or professional accrediting association and located within the United States or its possessions.

3. Contributions under the Program shall be employed by the college or university to realize or foster the primary needs and objectives of an institution of higher education, namely, of augmenting the required capital and general operating funds, of providing for expanded student enrollment, of strengthening educational facilities and curricula, and of improving incentives for the highest quality of teaching.

4. The employee at the time of his or her contribution shall be in the active regular employment of the General Electric Company or one of its wholly-owned subsidiaries and shall have had at least one year of continuous service in such employment.

5. The total contribution under this Program with respect to the contribution or contributions of any individual employee shall be limited to the sum of $1,000 and the total contributions to be made by the Fund under the Program shall not exceed the amount appropriated by the Trustees of the Fund for this purpose. In the event that total employee contributions otherwise coming within the terms of this Program exceed the amount so appropriated by the Trustees, the contributions to be made by the Fund under this Program may be apportioned by the Trustees in such a manner as they may consider equitable and proper.

6. The Trustees shall be entitled, if they deem it desirable to do so, to suspend, revoke, or terminate this Program at any time with respect to employee contributions thereafter made.

7. Any question, whether as to the interpretation, application or administration of the provisions of this Program or otherwise, shall be determined by the Trustees and their decision shall be final.

For more information write: General Electric Educational and Charitable Fund, Corporate Alumnus Program, Schenectady, N. Y.

Progress Is Our Most Important Product

GENERAL ELECTRIC

FOOD

(*Continued from page 352*)

shipped to Catholic countries of the Old World, and cured fish became the colonists' capital resource and stock in trade. Cured fish was used for the purchase of manufactured goods from Europe, and of sugar, rum, molasses, and tobacco from the West Indies.

The fish-curing industry prospered and dominated the economic life of the New England colonies in the late Seventeenth and Eighteenth Centuries. In 1775, the British Parliament passed a bill prohibiting the New England colonies from trading directly with foreign countries. This prevented New England vessels from fishing in the Gulf of St. Lawrence, in the Newfoundland Banks, and on the coasts of Labrador and Nova Scotia. Ruin faced the New England fish-curing industry, and the edict was one of the leading causes of bringing these colonies into the Revolutionary war.

Butter and cheese were made on every farm, but in general they were not of such quality as we know them today. Their manufacture required more care and attention than the ordinary farmer could afford. For this reason, city dwellers throughout the Seventeenth Century (and until the end of the Eighteenth Century) imported at least part of their butter from England and Ireland.

The dairy cow of colonial times was a sorry creature; she was ill-fed and gave little milk. Despite the low yield, milk was quite plentiful in the northern colonies, but it was scarce in the southern colonies where the heat made it difficult to keep milk fresh. The market for milk was limited by difficulties of transportation, and even in the larger towns, such as Boston, cows were kept by almost every dweller. There the Common was the community grazing area, and the meandering cowpaths to the Common might have been the forerunners of Boston's present winding, narrow streets.

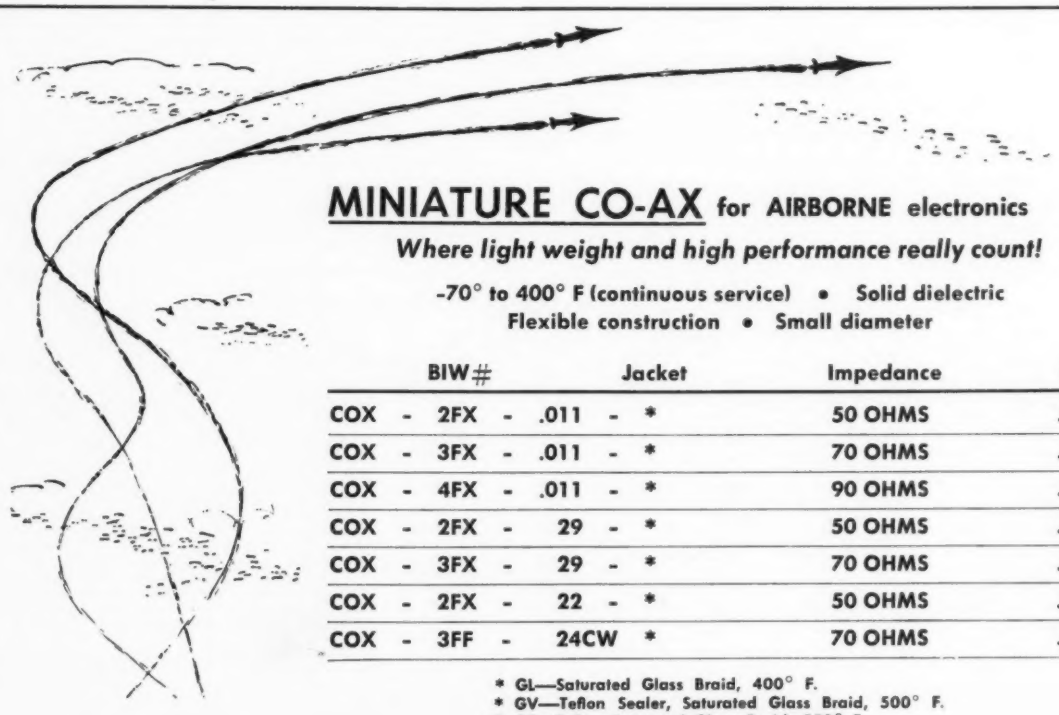
A town officer, known as the "cowherd," drove the cows to the grazing area in the morning and back again at night. Since his duty was to stay with the herd all day, he must have had plenty of time for thinking. Thoreau's statement, "I would rather sit on a pumpkin and have it all to myself than be crowded on a velvet cushion," may have reflected the thoughts of a past cowherd reposing in a sweet-smelling, shaded New England meadow.

Even ice cream was known to the colonials. At a dinner in the first half of the Eighteenth Century given by Governor Bladen of Maryland, William Black records in his journal:

> A Dessert no less curious among the Rarities of which it was Compos'd, was some fine Ice Cream which, with the Strawberries and Milk, eat most Deliciously.[17]

In 1777, Philip Lenzi, a confectioner in New York, was making ice cream which he advertised in the local papers of the time,[18] and in 1789, ice cream

(*Continued on page 356*)



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COX - 4FX - .011	- *	90 OHMS	.125"
COX - 2FX - 29	- *	50 OHMS	.080"
COX - 3FX - 29	- *	70 OHMS	.100"
COX - 2FX - 22	- *	50 OHMS	.130"
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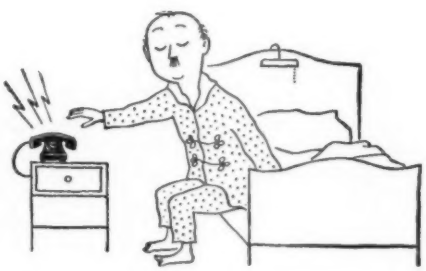
Telephone Diary

HOUSEWIFE TELLS HOW FAMILY'S TELEPHONES SAVE STEPS, TIME AND WORRY—DAY AND NIGHT



4 A. M. Jack's a sound sleeper but he woke up fast when he heard the news. "It's a boy!" he shouted. "Nearly eight pounds. Mary's fine." Then I talked and Jack talked. Bless that bedroom telephone!

8 A. M. to 11 A. M. Just couldn't wait to tell Betty and Peggy about the baby. Then I ordered Jack's favorite roast for dinner and was lucky to get a hairdresser appointment. A grandmother must keep young!

5 P. M. Wouldn't you know! The very night I have something special for dinner Jack gets held up at the office. But it wasn't too bad. He telephoned he'd be an hour late. It's wonderful to have a telephone in the kitchen.

10 P. M. Such excitement! First Jack Jr.'s baby. Then Alice tells us she's engaged. I wasn't too surprised because of all those telephone calls and dates. I'm so glad it's that nice Bob Johnson.

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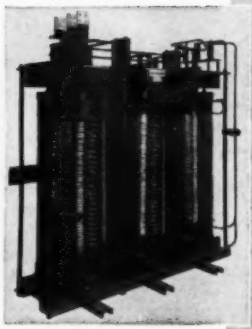

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Elton E. Staples, '26, *Exec. Vice President*
Chester Meyer, '36, *Works Manager*

FOOD

(*Continued from page 354*)

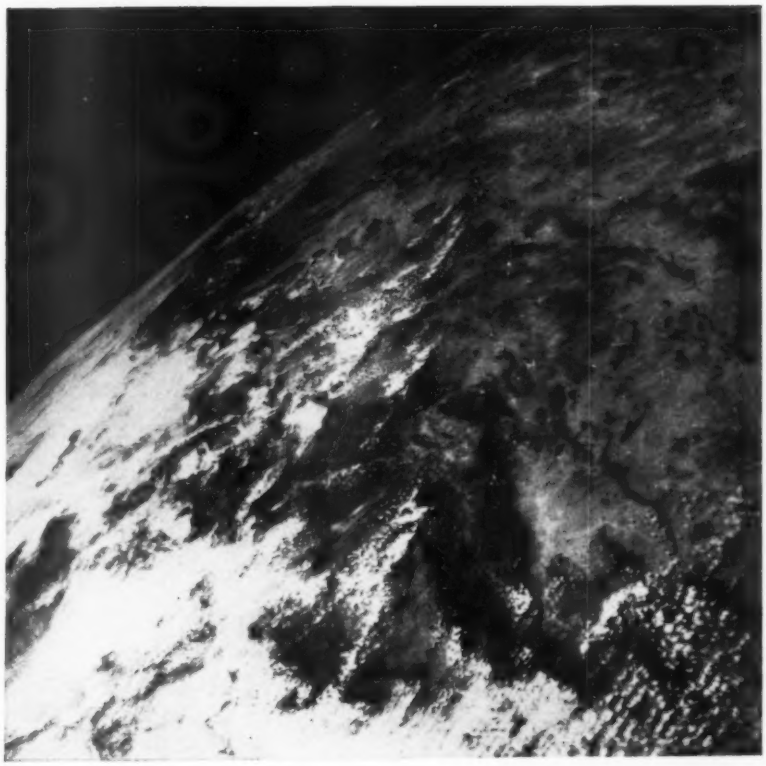
was served at a dinner given by George Washington.[19]

Maple sirup and sugar were made in the back country of the colonies, and nearly every farm had a collection of hives so that honey was available. Although sugar cane was grown to a limited extent in southern Georgia, almost all of the sugar used in the colonies was imported from Jamaica, Nevis, and the Barbados. In the years 1677–1678, as much as 190,436 pounds of sugar was imported from these countries into Virginia; 10,525 pounds into the Carolinas; 655,921 pounds into New England; and 30,550 pounds in New York.[20] All of this sugar was not consumed in the colonies. The development of intercolonial trade had been such that the continental colonies regularly exported their products to the West Indies and in return, received from the Indies sugar, tobacco, molasses, and so on, which the colonists in turn sent to Europe. Sugar came in 15-pound cones, wrapped in blue paper, having considerable end use for decorative purposes. In the household, sugar was kept securely locked in a sugar chest, which was, quite often, of intricate ornamental design. Sugar was cut from the cone by shears.

As a protest against tea taxation, a chocolate mill was built in Massachusetts in 1760[21] Coffee was also used as a substitute for tea. "Madam," asked John Adams of Mrs. Huston at Falmouth, "is it lawful for a weary traveler to refresh himself with a dish of tea, provided it has been honestly smuggled or paid no duty?" The answer was to the point. "No, sir, we have renounced all tea in this place, but I'll make you coffee."[22] The Pennsylvania Dutch (settlers from The Palatinate of the Rhine Valley) made "coffee" of burnt rye or wheat, the forerunner of our coffee substitutes of today. A coffee substitute was also prepared from diced, roasted potatoes. Around 1772, attempts were made to raise tea in Georgia, and even as late as 1857 it was suggested that tea could be grown in the southern part of the United States in a broad band extending from the Atlantic to the Pacific Coast.[23]

It was easier and more profitable to produce food in the southern colonies than in the northern. The mild climate and slave labor in the South made living more favorable. The rocky and wooded hillsides and unfavorable climate of the northern New England colonies did not permit widespread farming operations. The home life of the average New England rural family, although wholesome and practical, was arduous. Toil from sunup to sundown was the routine, and by nine o'clock at night no candles twinkled in the windows of the lonely farmhouses. The strong religious coloring attached to all life in New England gave work there a significant moral virtue, and idleness was considered a sin. Hard and honest toil complied with the will of God; success in one's work was a just reward from the Lord, the fruits of which were not to be wasted on the frivoli-

(*Continued on page 358*)



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FOOD

(*Continued from page 356*)

ties of life. A colonial farm supper was simple: the children ate milk porridge or hasty pudding, while father and mother had a slice of cold pork, brown bread, and a mug of beer. Brayley makes the following comments:

At the close of the 18th Century the poverty of the masses made simplicity of living a necessity, and any cooking requiring sugar was too expensive for them. The noonday meal dispatched in 15 minutes began with Indian pudding, relished with a little molasses. Next came a piece of boiled salt pork with cabbage, or black broth, fried eggs, brown bread, and cider. The dinner of "boiled victuals" was served in wooden trenches. The meat of the shagbark§ was dried and pounded and then put in their porridge to thicken it. Barley firecake was served at breakfast. They parched corn and pounded it and made it into no-cake. The extra dish for company was a cake made of strawberries and parched corn. Baked beans, baked Indian pudding, and newly baked rye- and-Indian bread on Wednesdays and salt fish regularly on Saturday are historical dishes. Tobacco, which was early cultivated, was considered essential to health and comfort, and at one time every farmer had his tobacco yard as well as his cornfield.[24]

Present-day nutritionists would undoubtedly gasp at this diet, but at that time there was not sufficient knowledge to appreciate the inadequacy of such a fare. The science of nutrition had to wait until the middle of the Nineteenth Century before light began to dawn on this important field. Spruce beer, made by boiling the bark and leaves of the spruce, was in common use and a generally accepted antiscorbutic during the Eighteenth Century.[25]

It is apparent that our colonial forefathers had no conception of vitamins or balanced diets. Yet on a miserable fare of salt pork, corn, molasses, and rum, and plagued by hidden hunger, they carved a great country from the wilderness. It is true that they did not live as long as we do today. But it is equally true that they learned more, feared more, enjoyed more, and prayed more during their average life span of about 45 years than we do today in our span of some 60 years.

(*Continued on page 360*)

§ Apparently a hickory, *Carya ovata.*

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Hughes, pioneer developer of airborne digital computers, and leader in radar fire control, now enters the field of ground radar and data processing systems.

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FOOD

(*Continued from page 358*)

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(*Concluded on page 362*)

A Report

TO M.I.T. MEN

In 1917 Walker Memorial Building was opened, a gift from Alumni for the welfare of M.I.T. students. In addition to including offices for student activities and serving as a student social center, this building houses the dining service.

In 1953-54 nearly one million meals were served to staff and students and 57 dances, receptions and balls were held in Morss Hall. Morss Hall seats approximately 500 people. Thus, each chair served 2,000 people per year or 5.5 persons per day. We thank the Alumni for making these services possible.

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FOOD

(*Concluded from page 360*)

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CERRO BOLIVAR ORE

(*Continued from page 342*)

and a constant commuter was George S. Colley, Jr., President of Constructora Bechtel.

To all visitors, it was an unforgettable experience to stand on the slopes of Cerro Bolivar with some of the men in immediate charge of development and examine samples of ore – particularly on the eve of production. On November 27, power shovels on the hillside worked with special intensity. They were loading dump trucks in quick succession. The trucks rolled to a temporary platform alongside the track. Here were standing the first ore cars to have been put ashore at Puerto Ordaz only a few days before. They had since been hauled to Cerro Bolivar and were now receiving their initial consignment of ore. One of the most interested of spectators was Graham Lancaster, Vice-president and resident manager of Orinoco Mining Company.

A 60-car trainload was being made up for an experimental, inaugural run from Cerro Bolivar to Puerto Ordaz, with some 4,000 tons of ore. It was on a Sunday, when track work was at a minimum, that the ore train began its descent from the hill. The train was on the steepest grade on the entire line – three point one per cent. Three Diesel-electric locomotives of 1,600 horsepower apiece pulled the 60-car train. When mining operations were in full swing, there would be as many as 120 cars at a time.

(*Continued on page 364*)

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CERRO BOLIVAR ORE

(*Continued from page 362*)

As the first ore train neared the end of the line, another milestone in the history of the Orinoco Project was passed. Soon the ore brought by that train would be crushed, stockpiled, and poured into ships which would carry it to blast furnaces in the United States.

Loaded cars from Cerro Bolivar were shunted to the base of a ramp, and from there they were fed into a massive steel frame. One after another, at a rate up to 67 per hour, their loads were dumped into a giant primary crusher. As soon as each car was emptied, its place was taken by another. Eighty tons or more at a time were dropped into the crusher.

Here began an extraordinary procession. Out of a tunnel from the primary crusher pit moved the ore on a five-foot-wide belt, and upward to a secondary crusher which reduced all chunks from a maximum of nine inches in diameter to five inches or less. The belt system, at a speed of 600 feet per minute, swept the ore aloft to the bridge – a huge movable structure mounted on rails, with a span of 400 feet. The ore cascaded onto a storage pile that could grow to 700,000 tons.

Under concrete slabs at the base of the pile were two parallel tunnels in each of which were two traveling plow feeders. Huge, bladed arms, rotating horizontally, scraped the ore from a shelf onto a collecting belt. A river of ore flowed toward its destination. It passed through a plant which automatically weighed and sampled it. Thence it was shifted to a transfer house, where the belts changed direction and ran it out along the dock.

In the transfer house, an operator at a central panel could control every phase of the entire operation, with constant two-way communication all the way from the car dumper to the dockside.

By means of a loader moving on rails along the dock from one hold to another, ore could be fed into ships at a rate up to 6,000 tons per hour. This might one day be increased, with the installation of additional equipment, to as much as 12,000 tons.

January 9, 1954, was a gala day for the people of Puerto Ordaz – a day that began at the local airport, when reporters, photographers, and distinguished visitors from Caracas arrived in special airplanes. Most distinguished of all the visitors was Colonel Marcos Pérez Jiménez, President of Venezuela, who came to inaugurate the operations of Orinoco Mining Company and to dispatch the first cargo of ore.

The President, his party, and all the guests drove in official and private cars from the airport to the dock. A decorated and canopied flatcar served as a speakers' platform, and a crowd of Venezuelans and North Americans gathered expectantly before it. The Bishop of Guayana bestowed his blessing and Francis Thomas spoke on behalf of Orinoco Mining Company. Then Pérez Jiménez spoke:

(*Concluded on page 366*)

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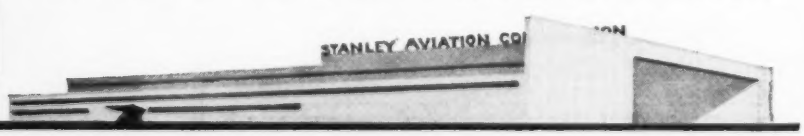

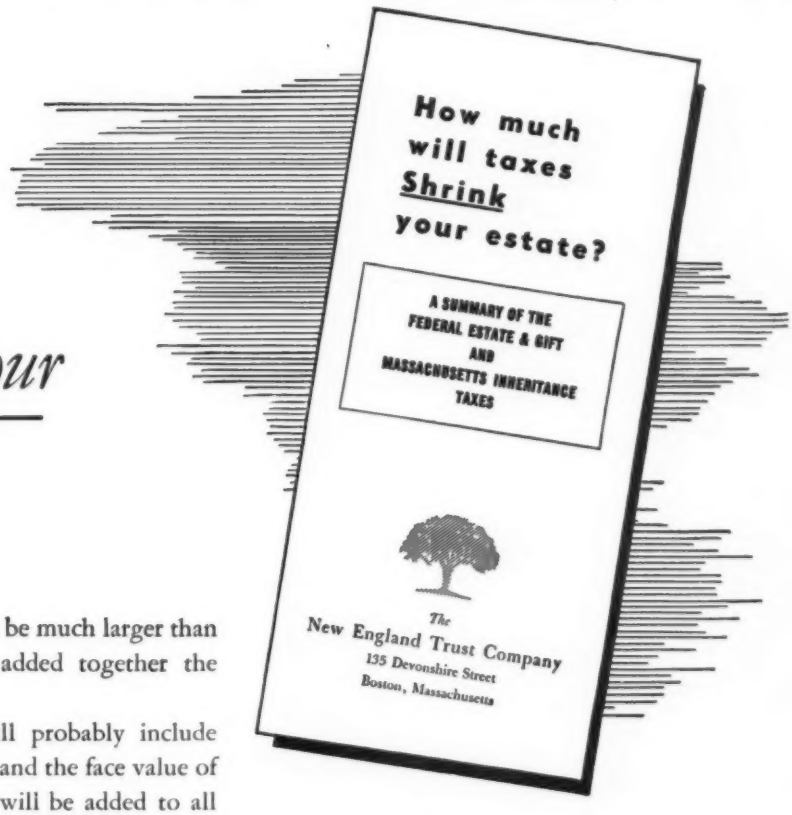
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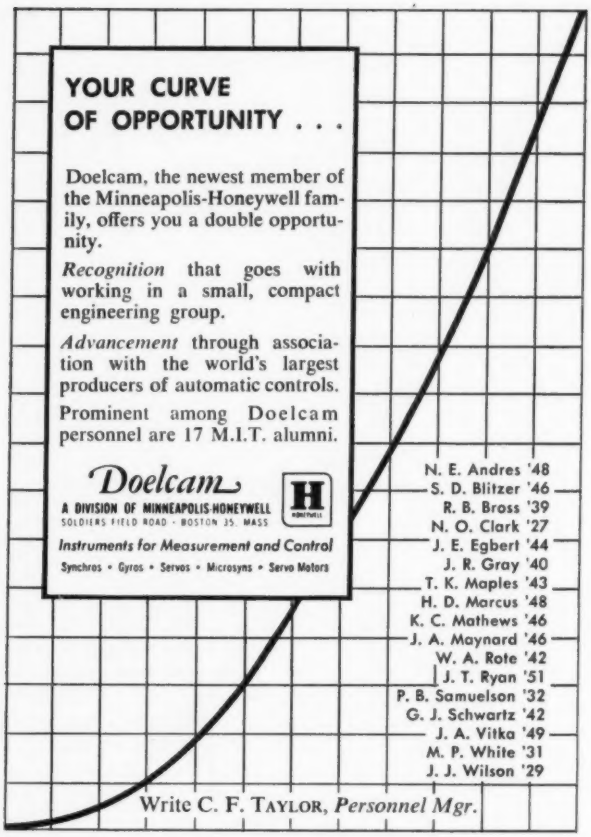
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CERRO BOLIVAR ORE

(*Concluded from page 364*)

"The first shipment of iron ore from Cerro Bolivar leaving this port is of great importance to Venezuela," said the President, "as it marks the beginning of the technical development of this valuable wealth on a large scale . . ."

The President pressed a button that caused the ore-handling machinery to go into action for the pouring of the last few tons to complete the loading of the first ship to carry Cerro Bolivar iron ore from Puerto Ordaz. It was a ship called the *Tosca* that had the honor. She was bound for the East Coast of the United States with 6,000 tons.

Ten days later, and 2,000 miles from Puerto Ordaz, a proud ship steamed up the Delaware River. Her immediate goal was Philadelphia. As she approached the historic city she was escorted by a flotilla of tugs and fireboats. A delegation boarded the *Tosca* to bid welcome to her and her captain. The hatches were open to display the cargo. In the group were the mayor and the Venezuelan Ambassador, the American Ambassador to Venezuela, the chairman of the Port Authority, and Clifford Hood, President of U. S. Steel. Gifts were exchanged, including a silver box of Cerro Bolivar ore which Captain Svante Hedin presented to the City of Philadelphia.

On went the *Tosca* 30 miles farther upstream to complete her voyage. She tied up to a dock near Morrisville, Pa., the home of the new Fairless Works, where iron ore from far places was being smelted and processed. On the morning of January 20, the dock was closed in by mist which lent an aura of drama to the scene as diplomats, officials of United States Steel, reporters, and photographers gathered to witness the unloading of the first iron ore from Cerro Bolivar. It was Benjamin Fairless who gave the word to the operator of the boat unloader:

"Frank Rossi, are you ready?"

"Yes, Sir, Mr. Fairless."

"Proceed."

"Here it comes."

This ceremonial sample of ore spilling into a box was the first fruit of years of exploration, of planning, and of labor. But not on the part of U. S. Steel alone. It was the result of a co-operative effort in which the people and the Government of Venezuela joined; and it exemplified what real and enlightened international co-operation could do to advance the welfare of mankind.

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GENIUS OF SAMUEL SLATER

(Continued from page 338)

authority. During a visit to New England in the year 1833, President Andrew Jackson was shown, in Pawtucket, a form of prosperity with which he had not been acquainted. To him, a Southerner, prosperity meant fertile fields of tobacco, rice, wheat, flax, indigo, rye, and, of course, cotton. This village of Pawtucket was prosperous because of its busy Slater Mill, which paid wages that enabled citizens of the village to live in warm houses, wear good clothing, and have plenty to eat – the measures of a comfortable standard of living for any community. The president was so impressed that he wished to see the man who was responsible for this pleasing situation, and when he learned that Samuel Slater was confined to his home with rheumatism, he and his Vice-president and members of his cabinet paid Slater a visit. Certain of the traits whereby Slater had achieved industrial success were similar to those that had made Jackson a successful President of the United States. The two elderly men thus had much in common, and they had a pleasant visit. At the end, the President said:

"I understand you have taught us how to spin, so as to rival Great Britain in her manufacture; you have set all these spindles to work, which I have been delighted in viewing, and have made so many happy by a lucrative employment."

"Yes Sir," said Slater, "I suppose that I gave out the psalm, and they have been singing to the tune ever since."

President Jackson could think of but one title for a man with Slater's amazing record – he greeted Samuel Slater as the "Father of American Manufacture," and the pleasant visit came to an end.

Epilogue

When Samuel Slater died, the three sons, whom he had taught his methods of textile manufacture, ably demonstrated their talent as they managed the great Slater estate bequeathed them. At the time, son George was 31, John was 30, and Horatio Nelson was 27. George and John died within a decade of their father's death, and it was left to young Horatio Nelson to carry on, in a manner that would have delighted his father. For Horatio Nelson continued to expand the Slater activities, keeping them to the forefront of the rapidly growing textile industry of America.

(Concluded on page 370)

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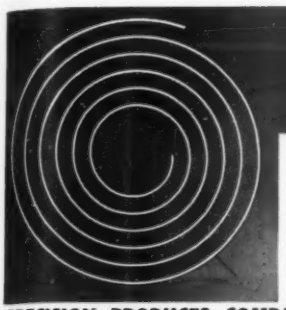

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GENIUS OF SAMUEL SLATER

(Concluded from page 368)

He had rounded out the combined activity of father and son to nearly a full century at the time of his death. Two years later, the great Cotton Centennial of the year 1890 was held in commemoration of the start by his father of America's first successful cotton mill in tiny Carpenter's Clothier's Shop in Pawtucket.

Today, father and son would join in their respect for later generations of Slaters, who have carried on in the fine tradition of their progenitor, Samuel Slater.

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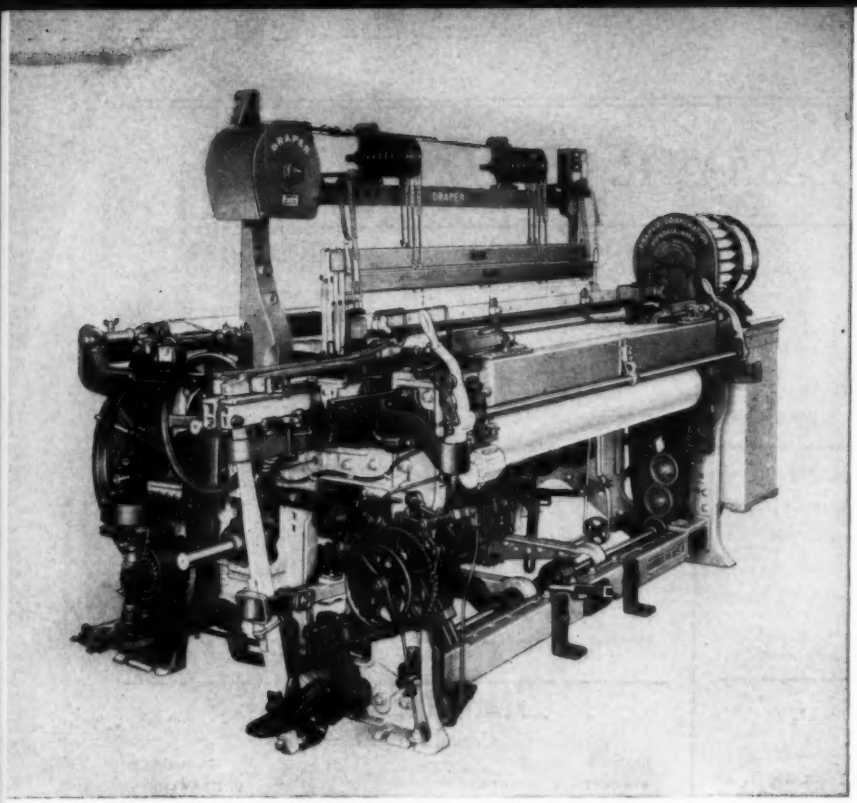

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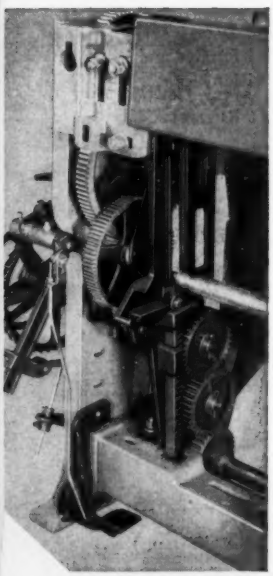

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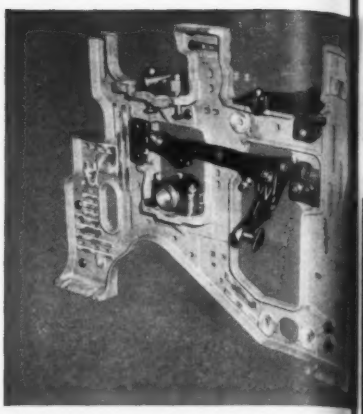

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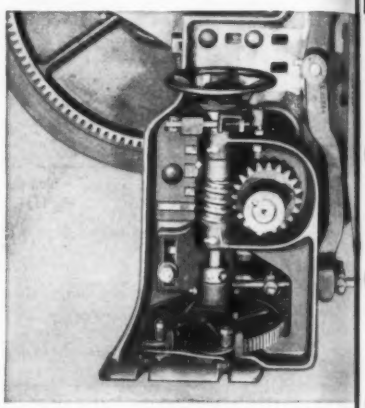

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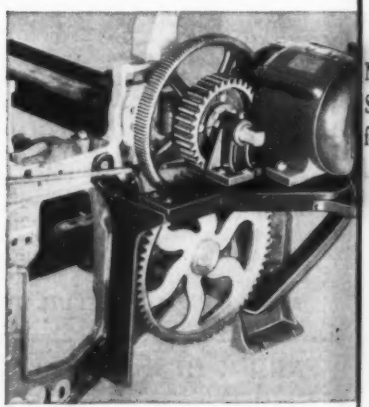

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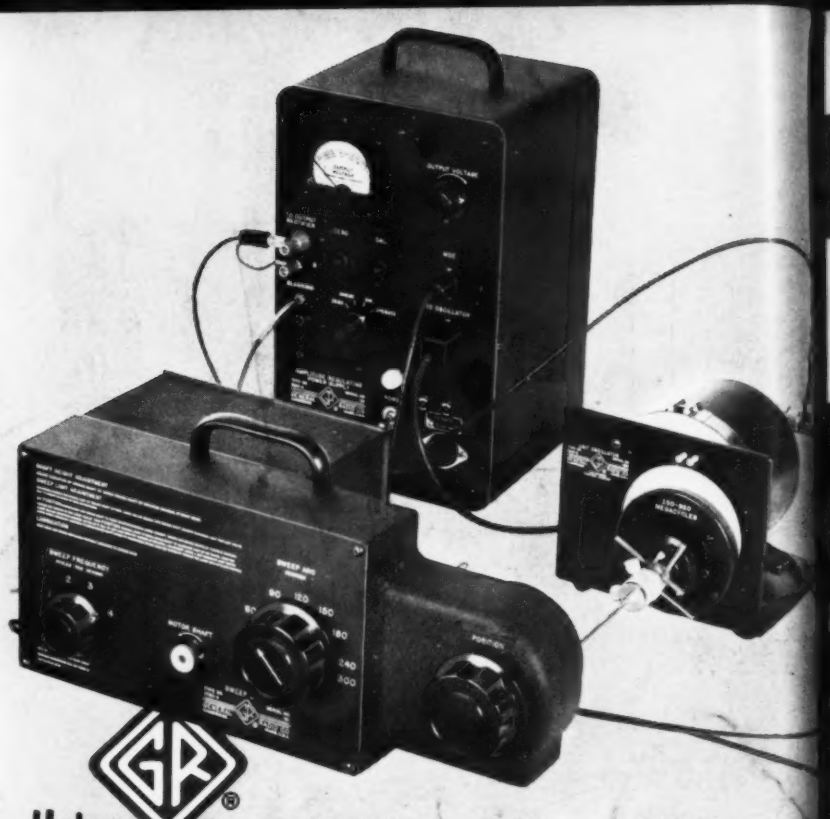

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